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Assessment of flood mitigation strategies for the city of Kalona, Ia

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ASSESSMENT OF FLOOD MITIGATION STRATEGIES FOR THE CITY OF KALONA, IA

by

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A thesis submitted in partial fulfillment
of the requirements for the Master of Science
degree in Civil & Environmental Engineering in the
Graduate College of
The University of Iowa

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Thesis Supervisors: Professor Larry Weber
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Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

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has been approved by the Examining Committee for
the thesis requirement for the Master of Science
degree in Civil & Environmental Engineering at the December 2015 graduation.

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ABSTRACT

In order to reduce flooding, communities often try to control runoff with a storm sewer network, detention basins, low impact developments, and upstream storage to reduce stream overflow. Numerical models can help predict the effect these strategies will have before expensive construction projects are underway. A coupled 1D/2D hydraulic model using XPSWMM was created for the town of Kalona, IA, to test different strategies for flood reduction. XPSWMM utilizes one dimensional and two dimensional St. Venant equations to model flow in streams and pipes, or overland flow on the surface, respectively. The town of Kalona, upstream highlands, and the downstream floodplains were modeled utilizing a 4 meter cell-size unstructured grid. The model was neither calibrated nor validated, but its performance was comparable to a previously built MIKE 11/21 model of the same area when given the same inputs.

The city drains into Salvesen Creek, the Central Drainage Ditch, and the East Drainage Ditch, with Salvesen Creek having the largest drainage area. 14 agricultural detention ponds upstream of the town were modeled to determine their effectiveness in reducing stream overflow, while modifications to the storm sewer network and *in situ* detention provided relief from local runoff. The detention ponds and modifications were modeled both separately and together and compared to a base model using the 10 year, 25 year, 50 year, 100 year, and 500 year, 3 hour storms.

The different methods were compared using three index points: City Hall, Pleasant View Circle, and in a softball practice area. The upstream agricultural detention ponds provided a peak reduction of 2%, 13%, and 9%, respectively, while the *in situ* modifications reduced flooding by 0%, 44%, and 18%, respectively, for the 10 year storm. The combined techniques reduced flooding by 2%, 44%, and 20%, respectively. During the 100 year storm, the detention ponds, modifications, and combined techniques reduced peak flood depths by 17%, 24%, and 14%; 2%, 3%, and 22%; and 17%, 55%, and 23%, respectively. This demonstrated that the *in situ* modifications were more effective during low flood events while ponds were more effective at high flood events. The combined approach was most effective when the two methods complemented each other. Future work might determine areas throughout the town where reduced flow and *in situ* modifications together would be most effective and design approaches to maximize flood reduction. Additional features to be modeled include pumps to increase capacity in the storm sewer network, levees, and supplementary drainage channels.

PUBLIC ABSTRACT

A hydraulic model of the town of Kalona, IA, was created to test two methods of flood mitigation. These methods included a distributed network of detention ponds to store water and release it at a much lower rate and *in situ* modifications to the storm sewer network. These scenarios were tested separately and together to determine their individual and combined impact on flooding. Maximum depths were recorded at three points of interest, Pleasant View Circle, The Softball Practice Area, and City Hall.

Flood and flood reduction maps were created to help decision makers decide which projects should be approved. For storms that have a 10% probability in a given year of occurring, maximum flood depths were reduced by 44% and 20% at Pleasant View Circle and an area south of the softball fields, respectively, using both the upstream detention ponds and *in situ* modifications. This reduction increases to 55% and 23% for Pleasant View Circle and the area south of the softball fields, respectively, as well as 17% at City Hall for a storm with a 1% probability of occurring in a given year. Only the detention ponds reduced flooding at City Hall, while the drainage network modifications were more effective at the softball practice area and Pleasant View Circle. The flood reduction methods were more effective when combined than either alone. Future work should focus on finding additional potential modifications or areas where the two methods together provide further flood reduction, as well as modeling other flood control measures such as levees, pumps, or additional channels.

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CHAPTER 1. INTRODUCTION

1.1 Motivation and Project Overview

During the summer of 2008, record floods devastated communities across Iowa. In response, Watershed Management Authorities were established throughout the state to help residents, private organizations, and local governments work together to solve basin scale problems. The English River Watershed Management Authority (ERWMA) encourages land owners, municipalities, and other administrations to come together to prevent flooding (English River Watershed Management Authority 2015). Kalona is the largest downstream community in the watershed, which has experienced numerous flood events in recent years. The purpose of this project is to model the entire Kalona drainage area and test local and basin scale strategies and create a plan to reduce flooding.

The Iowa Flood Center has conducted numerous studies in the area, including a hydrologic assessment of the English River Watershed and a flood model of the City of Kalona using the models DHI's MIKE 11/21 and HEC-RAS (Bradley 2015, IIHR - Hydroscience & Engineering 2014). The 100 year and 500 year flood plains along the English River were also delineated as part of the Iowa Statewide Floodplain Mapping Project (Iowa Flood Center 2015). Figure 1-1 shows the current 100 year and 500 year flood maps.

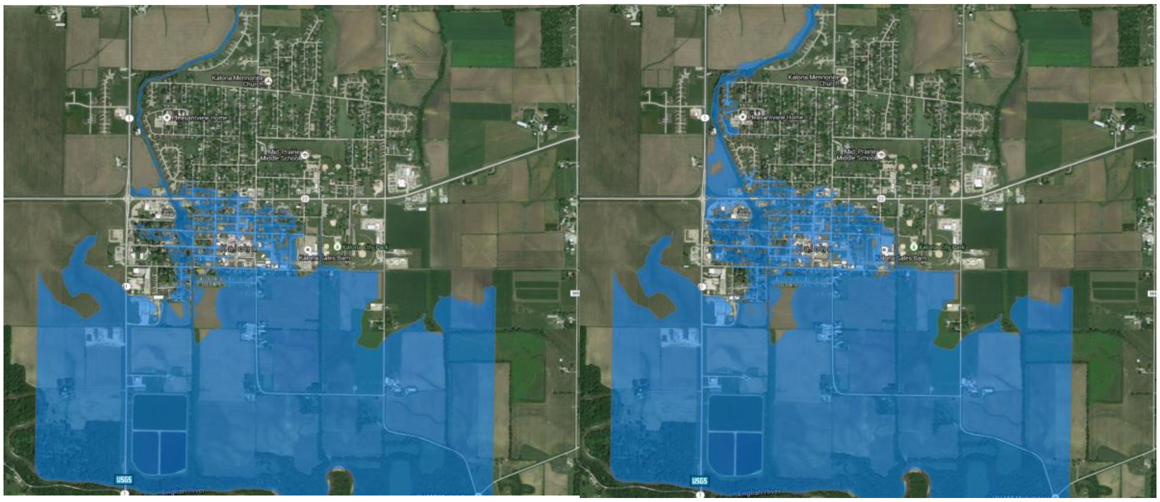


Figure 1-1: Existing 100 year (left) and 500 year (right) Flood Maps

However, due to the numerous streams and complex urban flow patterns within the town, existing models were incapable of simulating projects under consideration. A new model was developed using the software XPSWMM to simulate multiple streams over the entire Kalona drainage area while still utilizing a fine enough resolution to examine how water flows over streets, in between buildings, and becomes stored in detention basins (XP Solutions 2014).

Two flood mitigation strategies were pursued simultaneously: a distributed network of storage ponds upstream of Kalona and *in situ* strategies to reduce local runoff. The Iowa Flood Center would also like to test the capability of XPSWMM to determine its viability for future projects. If this platform provides more accurate results in an efficient manner over currently used software, then its use will be expanded to other projects.

CHAPTER 2. BACKGROUND INFORMATION

2.1 Literature Review

Models have been in use for several decades to simulate flows in urban areas and along rivers to learn how to reduce flooding. For example, some recent studies looked into urban low impact development (LID) techniques and levees along rivers (Chaosakul, 2013; Castellarin, 2011). Agricultural impoundments in southern Florida were modeled in DHI's MIKE SHE/11, and the Iowa Flood Center modeled the basin scale impact of potential distributed storage in the Chequest Creek, the Turkey River, and the upper Cedar River Watershed using HEC-HMS (Jaber 2005, Iowa Flood Center 2014). .

Basin scale storage was shown to reduce total runoff by a HEC-HMS model of the Soap Creek Watershed (The Iowa Flood Center 2014). This study examined how 132 prototype ponds built before 2013 performed during the 10, 25, 50, and 100 year, 24 hour Soil Conservation Service (SCS) design storm events at four points throughout the watershed. This distributed storage network was shown to reduce peak runoff by up to 40% for the smallest drainage area of 17,738 acres, and 27% for the whole 161,143 acre watershed. This showed that a distributed flood storage network can mitigate the impact flooding resulting from severe storms. Other strategies tested in the Soap Creek Watershed include modifying the soil and land use to increase infiltration. Changing the land use to native prairie grasses over row crops resulted in a maximum of 1.3% reduction of peak runoff flow. Improving the soil to encourage infiltration reduced runoff by a maximum of 13%. This study showed that a strategy of detention ponds spread over a watershed provides the most efficient reduction in peak runoff flows.

In addition to a distributed flood storage network, extreme rainfall events can be mitigated with an improved storm sewer network. Over time, urban areas develop and place increased stress on storm sewer networks (United States Geological Survey 2015). Increased urbanization decreases the infiltration capacity of an area, thereby increasing both the peak and the volume of runoff. Climate change also has an impact on the capability of storm sewer networks to drain urban areas (Bronstert 200). Networks designed to handle 25 year events can become overwhelmed more often as these events increase in regularity.

Waters (2003) modeled the impact of climate change on storm sewer networks using the software PCSWMM 2000 for Malvern, Ontario, by incorporating the networks into a one dimensional hydraulic model (Waters 2003). This network, designed and built in the 1960s, can handle a 2 year event. However, if the rainfall intensity increased 15% due to climate change, then multiple pipes surcharged. Measures to address decreasing network efficiency included pipe replacement, disconnection of impervious surfaces and increasing surface ponding and storage. This study showed that disconnecting impervious surfaces such as roofs had the most effect on reducing the runoff volume and peak discharge with 39% for both, while increased surface storage decreased volume and discharge by 20% and 18% respectively, and increased ponding storage decreased volume and discharge by 0% and 12.5%, respectively.

Upgrading the storm sewer network provides a promising strategy for reducing flooding as well. Using XPSWMM, the same software used for this thesis, Juan (2013) tested modifications to the network of Rice University in the Harris Gully Watershed (Juan 2013). Juan first created a 1D/2D model of the network and then updated it with larger pipe diameters in certain areas. These changes reduced flooding by 0.5 foot to 1 foot along the overland flood route above the pipes. These projects show that distributed storage networks and storm sewer upgrades can provide relief for flood risk communities and that various software packages can model improvements.

2.2 Discussion of the English River Watershed

The English River Watershed covers approximately 655 square miles, draining portions of Poweshiek, Iowa, Johnson, Mahaska, Keokuk, and Washington counties into the Iowa River near Riverside, Iowa. It is predominantly agricultural and contains the towns of Kalona, North English, Wellman, and Riverside, with Kalona being the most populous (Bradley 2015). Figure 2-1 provides an overview of the watershed's boundaries and points of interest (English River Watershed Management Authority 2014). The main crop covers include row crops such as corn and soybeans, grassland, and pastureland. Minor land uses are urban areas, prairie, and woodland.

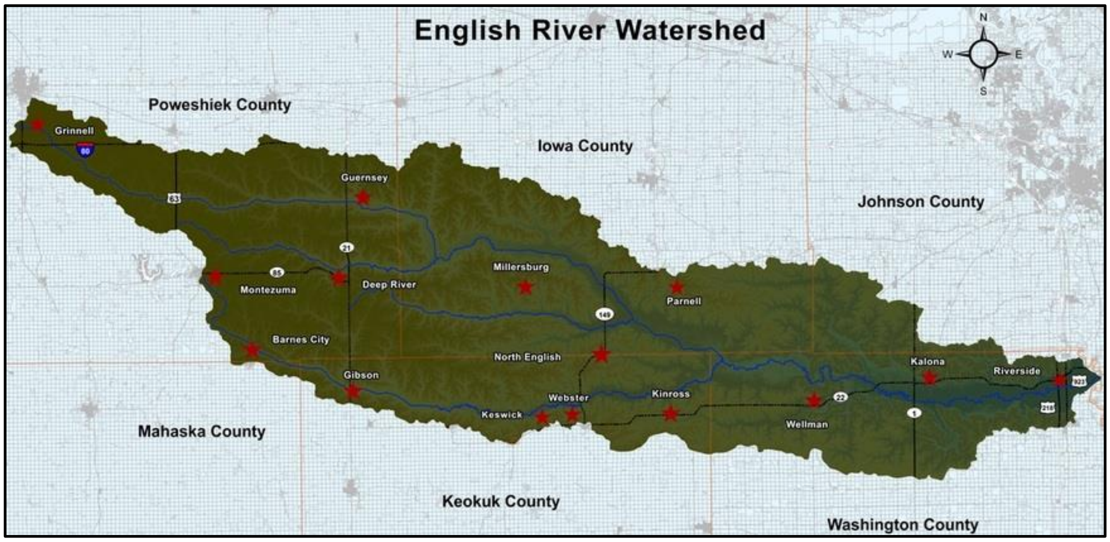


Figure 2-1: The English River Watershed (English River Watershed Management Authority 2014).

The only stream gauge on the English River is just south of Kalona on Highway 1. Although no rain gauges exist within the watershed, the seasonal distribution of rainfall was calculated by averaging 8 different gauges at Iowa City, Montezuma, Williamsburg, North English, Washington, Grinnell, Brooklyn, and Sigourney, based on their proximity to the watershed. Figure 2-2 and Figure 2-3 show the mean monthly discharge and precipitation for the area, respectively (US Geological Survey 2015, National Oceanic and Atmospheric Administration 2015). The spring months produce the highest discharges for the watershed are during the spring months while the summer produces the largest rainfall.

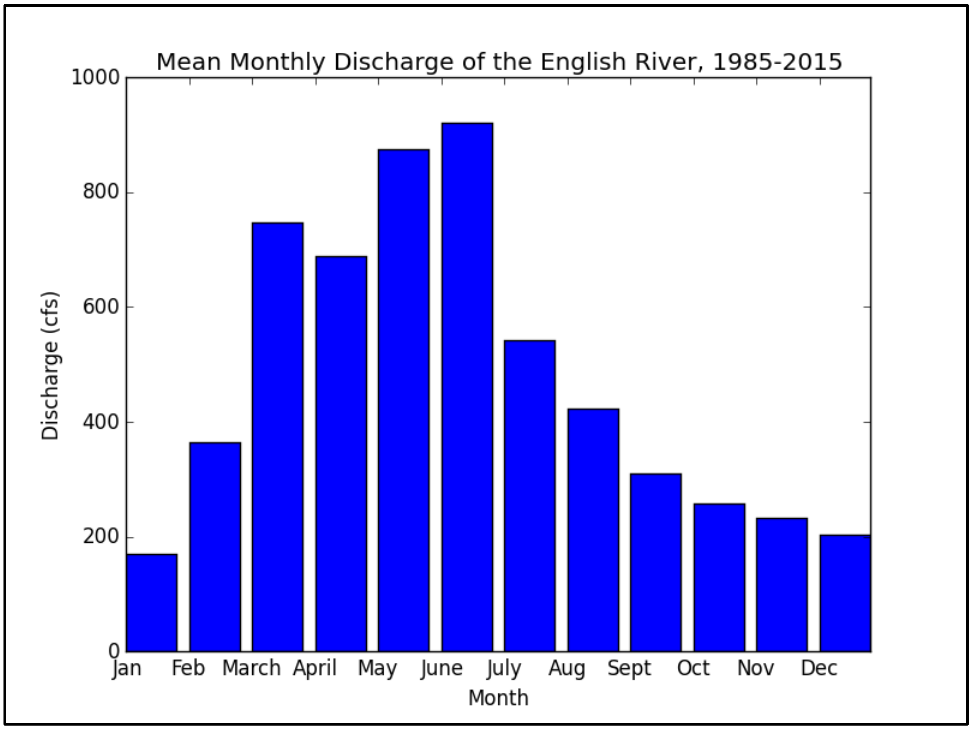


Figure 2-2: Mean Monthly Discharge of the English River, 1985-2015

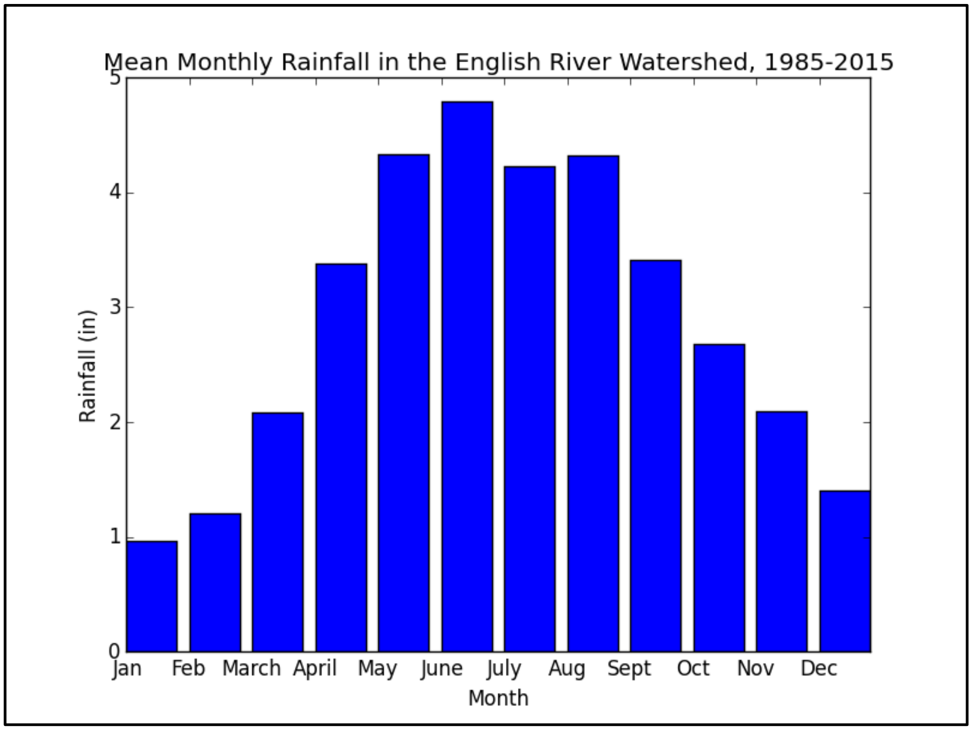


Figure 2-3: Mean Monthly Rainfall in the English River Watershed, 1985-2015

2.3 Discussion of the Kalona Drainage Area

Hosting a population of 2,400, the Kalona Watershed, hereafter referred to as the Kalona Drainage, comprises 12.8 square kilometers with its highest elevation at 241 meters and its lowest at 194 meters (US Census Bureau 2010, Iowa DNR n.d.) . The area is relatively flat, with the highest elevations and largest gradients in the northern highland areas, and the lowest gradients in-between the southern half of Kalona and the English River. Comprised primarily of agricultural and new residential areas, the northern highland has high runoff feeding into gullies and drainage creeks.

The floodplain includes the residential areas and the central business district, as well as agricultural fields and woodlands along the banks of the English River. Major routes through the Kalona Drainage include IA Highway 1 going north-south and IA Rt.-22 going east-west. Most of Kalona is to the east of Highway 1, with an addition to the west. Figure 2-4 shows the original 1 meter resolution digital elevation model (DEM) of the area taken by an airborne mounted LiDAR with an accuracy of ± 0.2 meters. The three major streams through the watershed are Salvesen Creek, the Central Drainage Ditch, and the East Drainage Ditch. Figure 2-5 shows the original 1 meter resolution topographic map of the floodplain between the English River and the City of Kalona. Any overflow from the river will inundate this area, potentially impacting the city. Several other drainage avenues form between 125th Street and the river, providing multiple flow paths in addition to the three creeks.

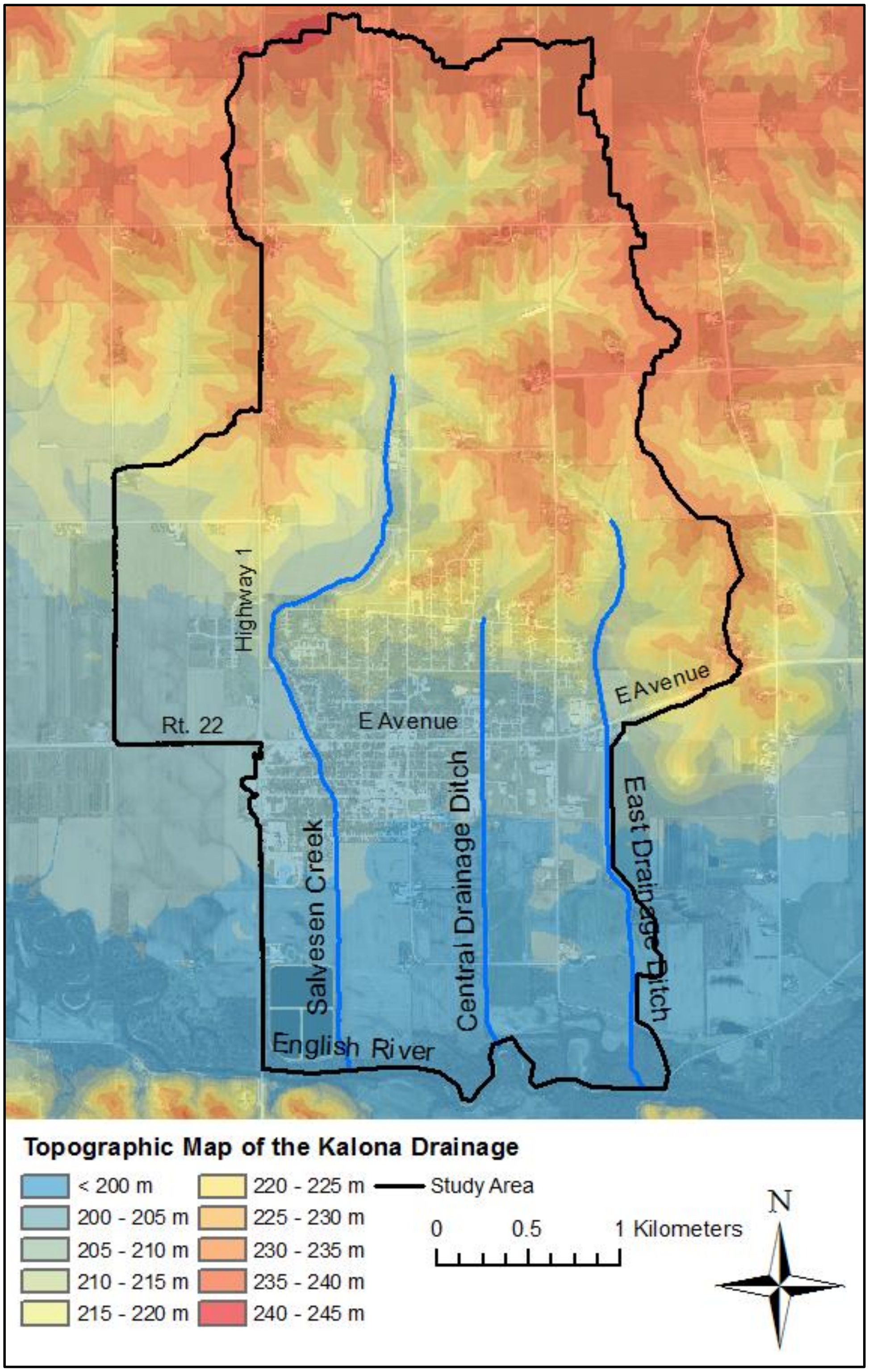


Figure 2-4: Original Digital Elevation Model of Kalona

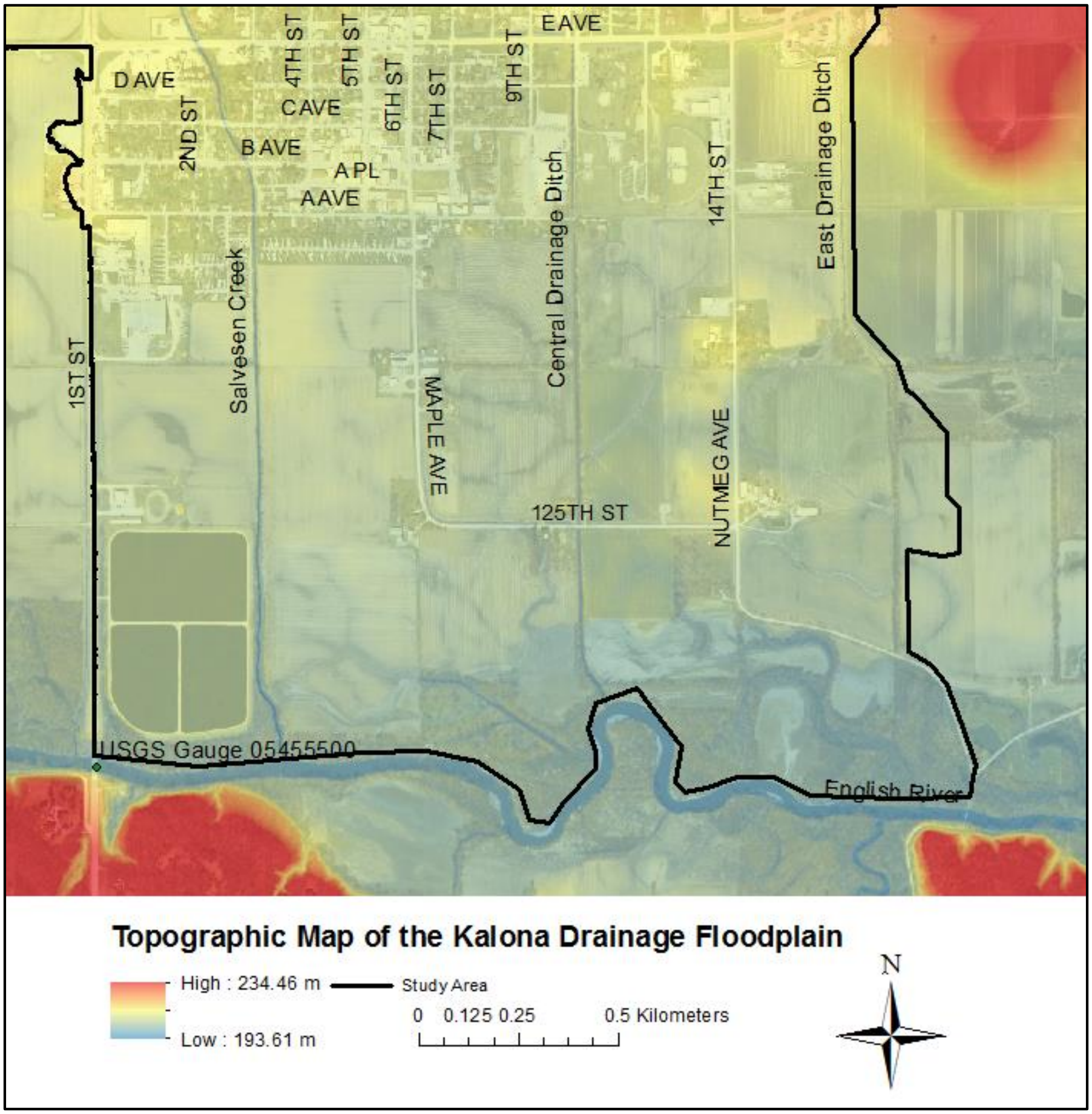


Figure 2-5: Topographic Map of the Kalona Drainage Floodplain

The area can be separated into 5 main catchments, each draining into a stream that runs through Kalona or directly into the English River. Figure 2-6 shows the catchments for Salvesen Creek, the Central Drainage Ditch, the East Drainage Ditch, Highway 1, and the Central Floodplain. The majority of the town drains into the Central Drainage Ditch, while the longest stream is Salvesen Creek. Only small sections of the town drain into the East Drainage Ditch or the roadside drainage ditch on the east side of Highway 1, and no portion drains into the Central Floodplain. However, there are no physical boundaries between these catchments, and runoff can easily cross from one to another.

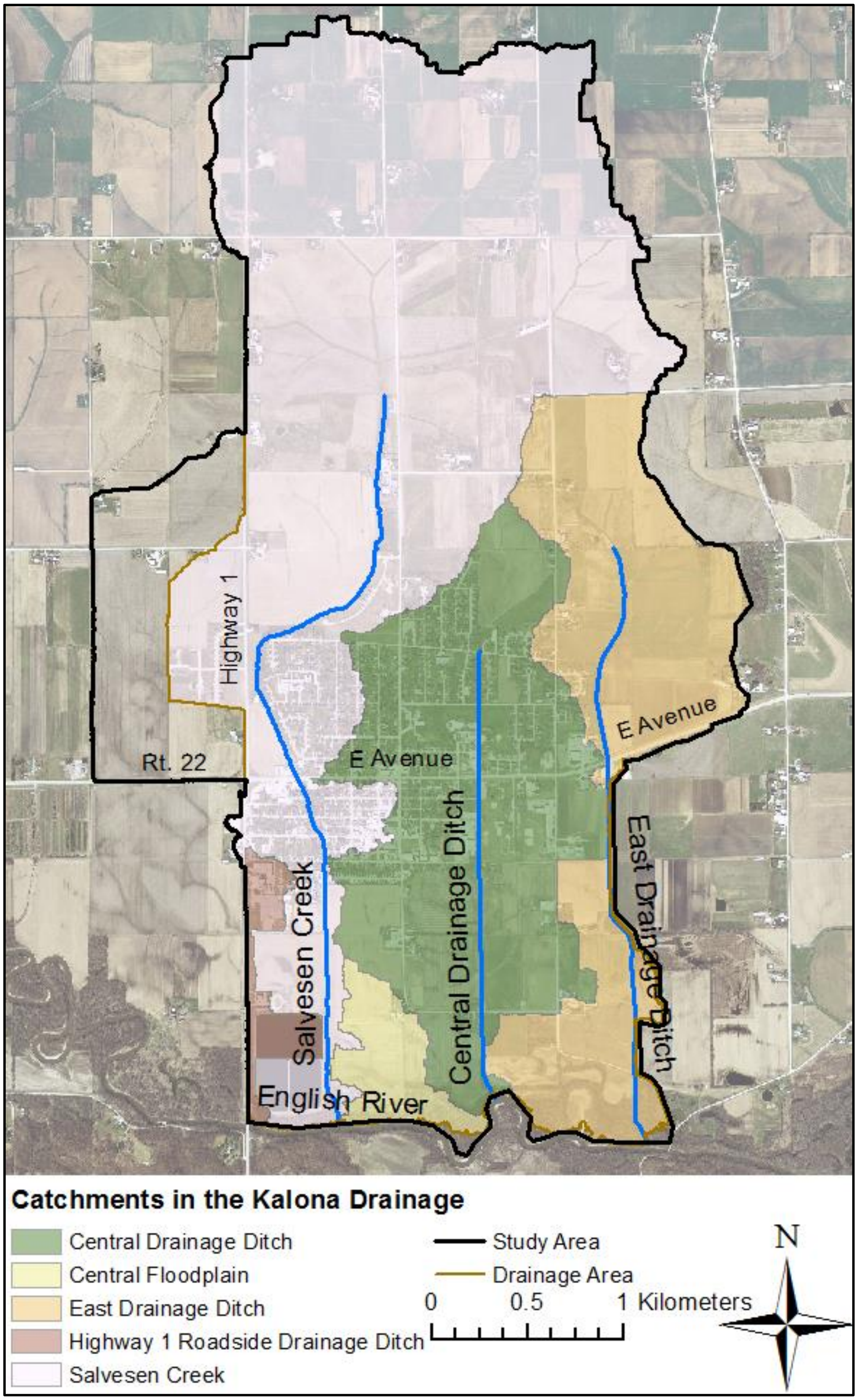


Figure 2-6: Catchments in the English River Watershed

For this study, the west drainage boundary near the addition west of Highway 1 was extended to include areas which might drain into Salvesen Creek or into the addition during extreme storm events. The Kalona Drainage was 75% agricultural, 21% urban, 3% woodland, and 1% surface water. Agricultural land was corn, soybean, and pasture while urban land was Kalona itself. The 2009 High Resolution Land Cover of Johnson County identified specific land use categories taken from the Iowa dataset provided by the Iowa DNR (Iowa Department of Natural Resources 2009). Figure 2-7 shows each of these categories with a 1 m resolution. Grass 1 and Grass 2 show areas with taller grass and shorter grass, respectively.

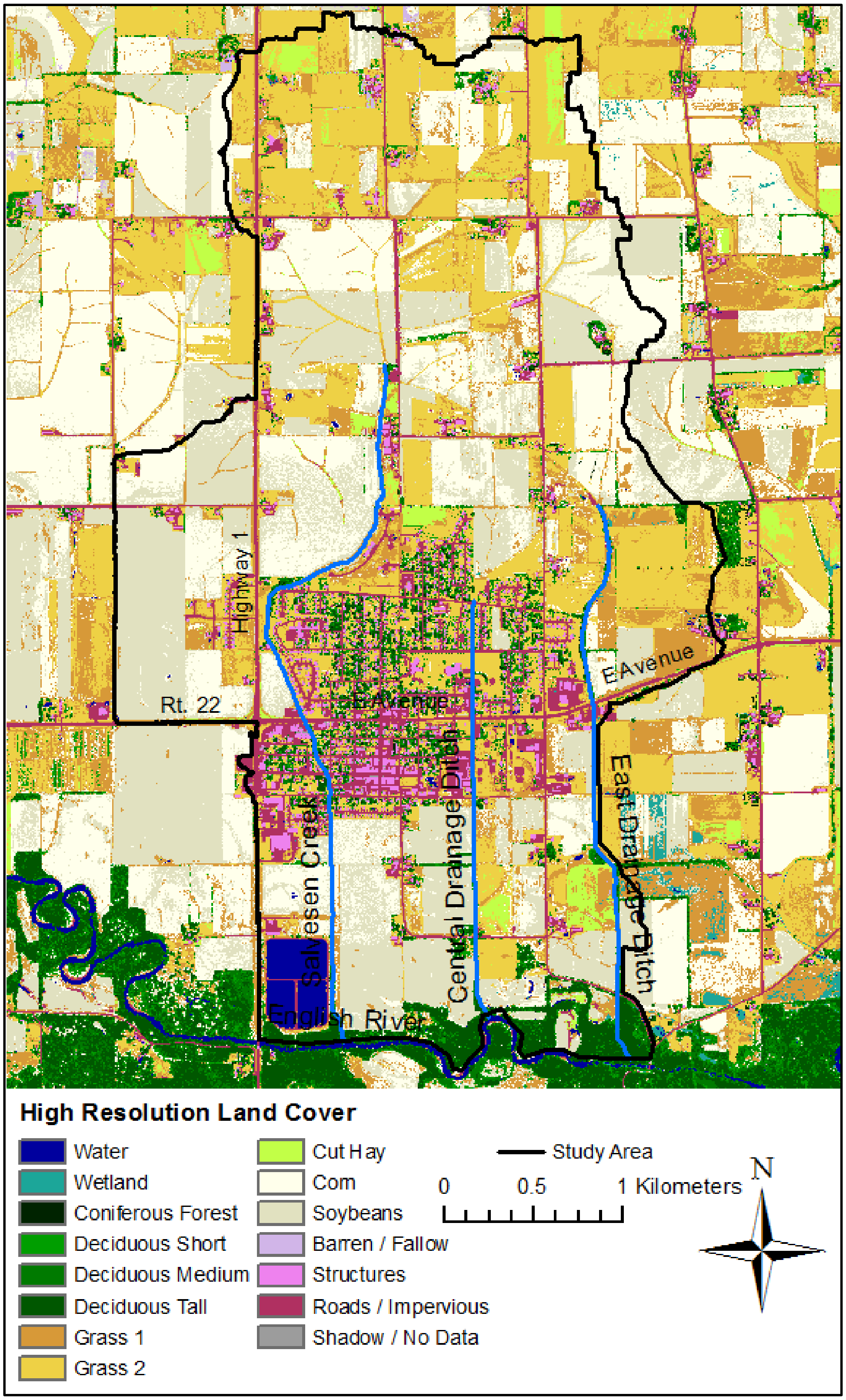


Figure 2-7: Original High Resolution Land Cover Dataset

2.4 Introduction to Modeling

Scientists, engineers, and planners often use computer models to simulate the complex interactions between stream channels, storm sewers, floodplain obstacles, etc. These computer models are designed to simulate how parameters such as stream flow, rainfall, and coastal tides, among others, act on a floodplain. They come in many different specifications for their intended use, desired investment, and computational constraints (N. M. Hunter 2007). Modelling software may be able to solve flow regimes in one, two, or three dimensions, based upon the expected conditions and modeling limitations. For instance, dam failure can have highly three dimensional properties, while flow in a storm sewer can be treated as one dimensional (Bates 2000). One dimensional models can only simulate known overland flow routes, while two dimensional models can help identify these routes.

Software such as EPA Storm Water Management Model (SWMM) and HEC-RAS can solve one dimensional, or 1D, models, which are adequate for large scale rivers or simple storm sewer networks (Horritt 2002). For complex urban flows, however, a two dimensional, or 2D, solver should be utilized. Large storms with interconnecting overland flow, structures such as bridges and culverts, and storm sewer networks requires the capability to model in both one and two dimensions, 1D/2D (Chen 2007). The mathematical difference between one dimensional and two dimensional models lies in their respective St. Venant, or shallow water equations (SWE). These equations are used to calculate the depth and velocities of water in the study area.

Each flow regime is based on the concept of continuity. Equation 1 shows the basic continuity equation for steady or unsteady incompressible flow (White 2011).

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \qquad (1)$$

From continuity, one can derive the momentum, or Navier-Stokes equations. If a Newtonian fluid with a constant density and viscosity are assumed, then Equation 2, Equation 3, and Equation 4 give the momentum equations in the x, y, and z plains, respectively:

$$\rho g_x-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)=\rho\frac{du}{dt} \qquad (2)$$

$$\rho g_y-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)=\rho\frac{dv}{dt} \qquad (3)$$

$$\rho g_z-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)=\rho\frac{dw}{dt} \qquad (4)$$

For each equation, ρ is density; g is gravity; x, y, and z are Cartesian coordinates; u, v, and w are the x, y, and z velocity components, respectively; t is time, and μ is viscosity. The SWE for both 1D and 2D models are derived from these equations. Equation 5 and Equation 6 show the resultant one dimensional continuity and momentum equations, respectively:

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=0 \qquad (5)$$

$$\frac{\partial Q}{\partial t} + \frac{\partial (uQ)}{\partial x} + gA\left(\frac{\partial h}{\partial x} - S_0\right) + gAS_f = 0 \qquad (6)$$

A is the cross sectional area, Q is the flow rate; t is time; x is distance in Cartesian coordinates; h is depth; S_0 is the longitudinal slope; and S_f is the friction slope. Common one dimensional models include EPA SWMM, PC SWMM, EXTRAN MIKE 11, HEC-RAS, ISIS, and InfoWorks-RS (Environment Agency 2009). These types of models split a river and floodplain area into a series of cross sections and assume that velocity is perpendicular to these cross sections. The water surface must also be horizontal across the cross section and the velocity is uniform within the cross section. These assumptions are most often valid if the water level is within the banks of the river or if the entire valley is flooded. During intermediate situations, however, the underlying velocity and depth assumptions can be incorrect. Therefore, splitting the floodplain and river into specific areas and modeling each individually as a storage cell is often necessary. This is the underlying concept of 2D models (Cunge 1980).

Equations 7, 8, and 9, give the basic depth-averaged two dimensional St. Venant equations (Gilles 2010):

$$\frac{\partial h}{\partial t} + \frac{\partial (hU)}{\partial x} + \frac{\partial (hV)}{\partial y} = 0 \qquad (7)$$

$$\frac{\partial (hu)}{\partial t} + \frac{\partial (hu^2)}{\partial x} + \frac{\partial (uv)}{\partial y} = \frac{\partial (hT_{xx})}{\partial x} + \frac{\partial (hT_{xy})}{\partial y} - gh\frac{\partial z}{\partial x} - \frac{\tau_{bx}}{\rho} \qquad (8)$$

$$\frac{\partial (hv)}{\partial t} + \frac{\partial (huv)}{\partial x} + \frac{\partial (v^2)}{\partial y} = \frac{\partial (hT_{xy})}{\partial x} + \frac{\partial (hT_{yy})}{\partial y} - gh\frac{\partial z}{\partial y} - \frac{\tau_{by}}{\rho} \qquad (9)$$

T_{xx}, T_{xy}, and T_{yy} are turbulent stresses; z is the water surface elevation; h is depth; τ_{bx} and τ_{by} are bed shear stresses; and u and v are velocities in the x and y direction, respectively. Two dimensional models use these equations to calculate how flow moves over a floodplains. The use of these models has increased since the 1980s as computational power improved, the software cost decreased, and local governments provided accurate spatial data (N. M. Hunter 2008). Common 2D software packages include LISFLOOD-FP, TUFLOW, Mike 21, TELEMAC, SOBEK, and InfoWorks-2D (Environment Agency 2009). Two dimensional models calculate how flow moves in the x and y directions in geographically defined cells, while assuming no acceleration in the z direction. Momentum can be preserved between cells, while flow and depth are calculated individually, allowing for accurate predictions of both rural and urban water levels. The cells can also be structured according to the topography, or of a defined, default geometry. Figure 2-8 shows an example of flow over an unstructured grid. Each grid elevation is defined by the elevation at the center point, while the water spills from one cell to the next.

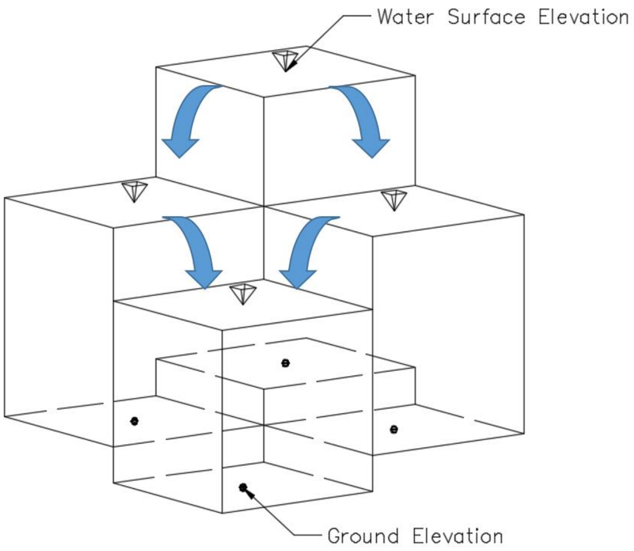


Figure 2-8: Example of Water Movement in a 2D Model

Two dimensional models have a greater advantage over one dimensional models because they can predict complex flow patterns that could be unknown or poorly understood. The flow patterns for one dimensional models are very limited because the velocity must be perpendicular to the cross sections. However, one dimensional models are often less expensive, easier to build, and use less computational power. They are also needed to accurately model structures such as culverts, storm sewers, and bridges because two dimensional models only use a grid. One dimensional models can also simulate channels with cross sections directly input into the interface, while vegetation, course grid resolution, and other factors can misrepresent areas on a 2D surface. For these reasons, strictly two dimensional software packages can be inadequate or inaccurate for some streams and wooded areas. Many software packages combine the benefits of both modeling techniques by coupling one dimensional and two dimensional solvers (Environment Agency 2009).

2.5 Introduction to XPSWMM

The software package used in this study, XPSWMM, combines an internal one dimensional calculation built off of EXTRAN, with the two dimensional solver XP2D, based on TUFLOW (XP Solutions 2014). XPSWMM was chosen for this study because it was approved by FEMA for use in the National Flood Insurance Program, was more economical than other similar software packages, had coupled 1D/2D capability, and could be used in other projects pertaining to IIHR-Hydroscience & Engineering's mission (FEMA 2015). The two dimensional model, XP2D, was developed by Stelling (1984) and applied as a commercial and research product by Syme (1991) (XP Solutions n.d.). Equations 10, 11, and 12 show the shallow water equations used in XP2D for continuity, x momentum, and y momentum, respectively:

$$\frac{\partial \zeta}{\partial t} + \frac{\partial (Hu)}{\partial x} + \frac{\partial (Hv)}{\partial y} = 0 \qquad (10)$$

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} - c_f v + g\frac{\partial \zeta}{\partial x} + gu\left(\frac{n^2}{H^{\frac{3}{4}}} + \frac{f}{2g\partial x}\right)\sqrt{u^2 + v^2} - \mu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial u}{\partial y^2}\right) + \frac{1}{\rho}\frac{\partial p}{\partial x} = F_x$$

(12)

$$\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} - c_f u + g\frac{\partial \zeta}{\partial y} + gu\left(\frac{n^2}{H^{\frac{3}{4}}} + \frac{f}{2g\partial y}\right)\sqrt{u^2 + v^2} - \mu\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right) + \frac{1}{\rho}\frac{\partial p}{\partial y} = F_y$$

(13)

Where ζ is the water surface elevation; u and v are the depth averaged velocity components in the x and y direction, respectively; H is the depth of water; t is time; x and y are distances; c_f is the Coriolis force coefficient; n is the Manning's Coefficient; f_1 is the energy loss coefficient; μ is the horizontal diffusion of momentum coefficient; p is atmospheric pressure; ρ is the density of water; and F_x and F_y are the sum components of external forces in the X and Y direction (XP Solutions n.d.). The computational procedure is an "alternating direction implicit finite difference method" (XP Solutions n.d.). It first solves the momentum equation in the Y direction for the Y velocities. Then it solves the continuity equation and momentum equation in the X direction to find X velocities and the water levels. The engine then repeats itself while solving the X momentum equation first, then the continuity and Y momentum equations. Information input into XPSWMM include topography, the 2D grid, 1D and 2D boundaries, land use categories, the 1D network, 1D/2D interfaces, and the boundary time-series data. Output information includes GIS formatted results, check files, and map data.

Groundwater flows and evaporation were considered outside the extent of this study. The model uses the Green-Ampt method to simulate infiltration which assumes a constant wetting front between dry and saturated soils in the water column (Chin 2013). Flow is calculated using Darcy's Law, with model inputs including soil porosity, suction, initial moisture, maximum ponding depth, and hydraulic conductivity.

CHAPTER 3. MODEL CONSTRUCTION

3.1 Chapter Summary

This chapter focuses on how the model was constructed and includes the delineated the 2D grid, DEM modifications, land use categories, soil types and infiltration, the 1D drainage network, 1D/2D boundaries, input rainfall, downstream boundary conditions, and the model's performance confirmation. It also lists sources for information; how it was collected, modified, and input into the model and describes assumptions made during the construction process.

3.2 2D Grid Delineation

The 2D grid incorporated the entire Kalona Drainage. A 4 meter cell size was chosen because this was considered fine enough to capture flow patterns between buildings while still being computationally efficient. A 2D time step of one second was used to ensure stability throughout the simulation. Each design storm simulation lasted 10 hours and took 17.5 hours to compute. Figure 3-1 shows an example of velocity vectors on the 2D grid. As can be seen, flow can still go between buildings at the 4 meter cell size.

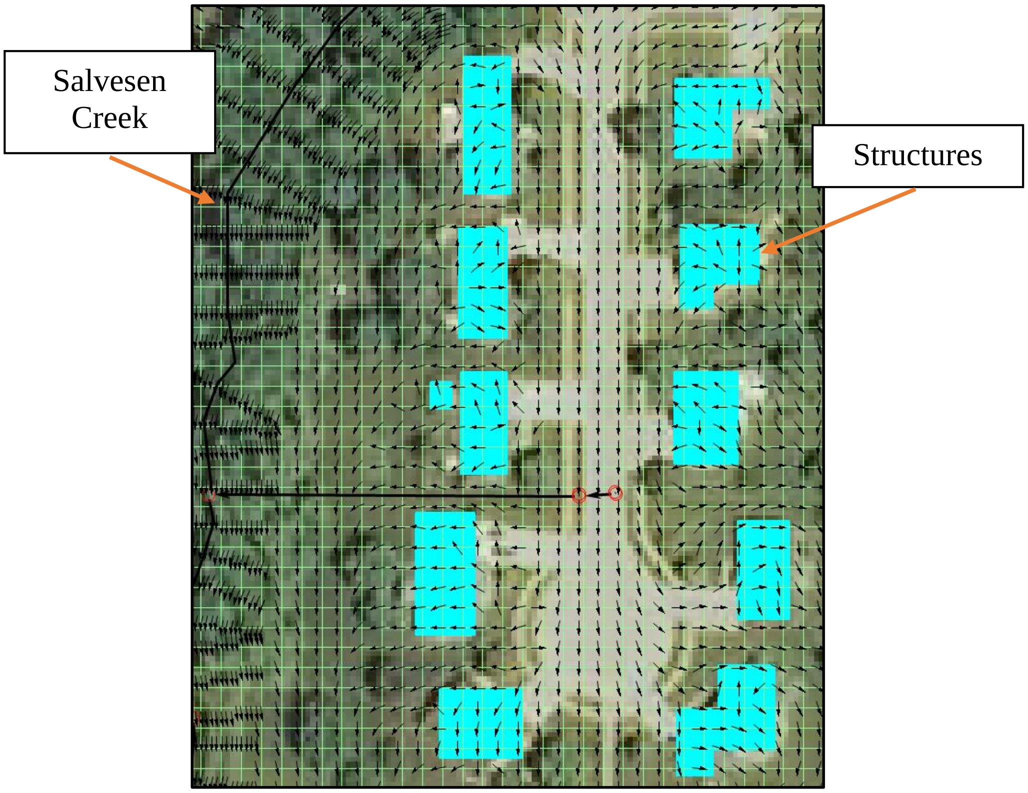


Figure 3-1: Example of a 4 meter Grid with Velocity Fields and Structures

3.3 DEM Modifications

Several modifications to the DEM were required to ensure an accurate representation of the drainage area. First, the East Drainage Ditch was burned into the DEM so that it could be accurately modeled in the 2D domain. Cross section and bridge survey information was used to create a surface that could be represented on the 2D grid. Figure 3-2 shows the original DEM and final modifications to a section of the East Drainage Ditch.

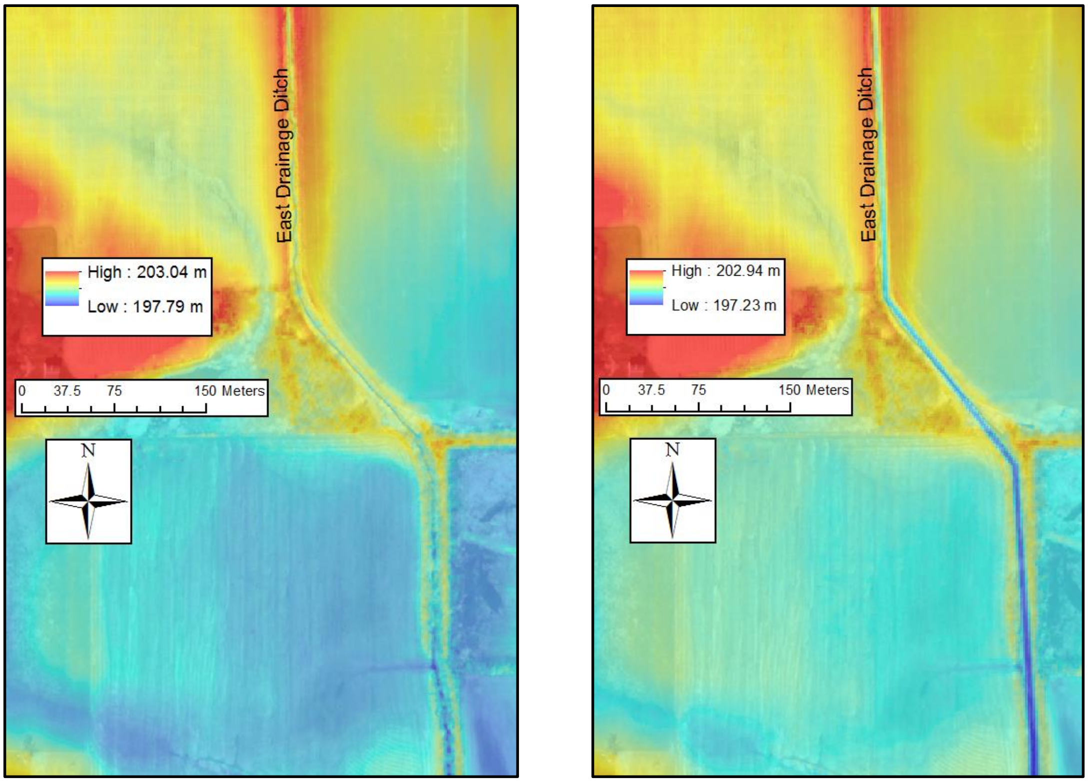


Figure 3-2: (Left) Original 1 meter DEM, (Right) 2 meter DEM with East Drainage Ditch Modifications

Other modifications to the DEM include the addition of the parking lot and drainage ditch just south of the Dollar General at 110 West H Avenue, Kalona. Since the DEM was created before this establishment was built, it had to be included manually with survey points taken from the site. Two dry detention basins and one detention pond were constructed since the creation of the DEM. The pond and one dry basin were built on the west and east side of Salvesen Creek, respectively, at the Maple Avenue Greenhouse, 1069 Maple Avenue. The other dry detention basin was built as part of a Mid-Prairie Middle School expansion project. Each basin was surveyed and input into the model's DEM.

Roadside drainage ditches were delineated by adding “gullies” to the model. Gullies are polylines which change the elevation of cells at the vertices and interpolating in between. Gullies were added to each ditch with the vertices at survey points taken at the upstream and downstream culvert inverts. This method was used on S. 6th Street, S. Maple Avenue, and 125th Street until they drained into the Central Drainage Ditch because the vegetation in the ditches obscured the LiDAR returns for the DEM.

3.4 Land Use Categories

Modifications were made to reduce the number of land use categories in the HLRC dataset from 16 to 7, simplify the different areas, and update the map with any changes since 2009. It was assumed that since the rainy season for Kalona is in the summer, all cropland will be almost fully grown and that the main agricultural products for the area are corn, soybeans, and pasture. Since corn and soybeans are both row crops, they have the same roughness coefficient and can be grouped together. When mature, row crops and high pastureland have the same Manning’s Coefficient (Chow 1959). Therefore, these were combined into one category. Deciduous and coniferous woodland units were combined to make a forest category. Open parkland and lawn surfaces, physical buildings and structures, and impervious surfaces were delineated within Kalona due to the amount of unforeseen obstacles in an urban floodplain, Other obstacles including driveways, trees, signs, vehicles and temporary structures, etc., were combined to form one “developed” land use category, while open fields with manicured grass such as detention basins, parkland, and mowed vacant areas formed a grassland land use category with a lesser Manning’s Coefficient than the developed category. Gravel, asphalt, and concrete roads and parking lots were combined to form the impervious layer, while all buildings were combined to form a structures layer. Surface water areas such as the wastewater treatment lagoon and filled storage areas in the northern highland areas were combined to form a surface water layer, while wetlands were merged with their surrounding layers. Figure 3-3 and Figure 3-4 show the modeled land use categories for the Kalona Drainage and a close up of Kalona itself, respectively. Table 3-1 lists each category and their respective Manning's Coefficient.

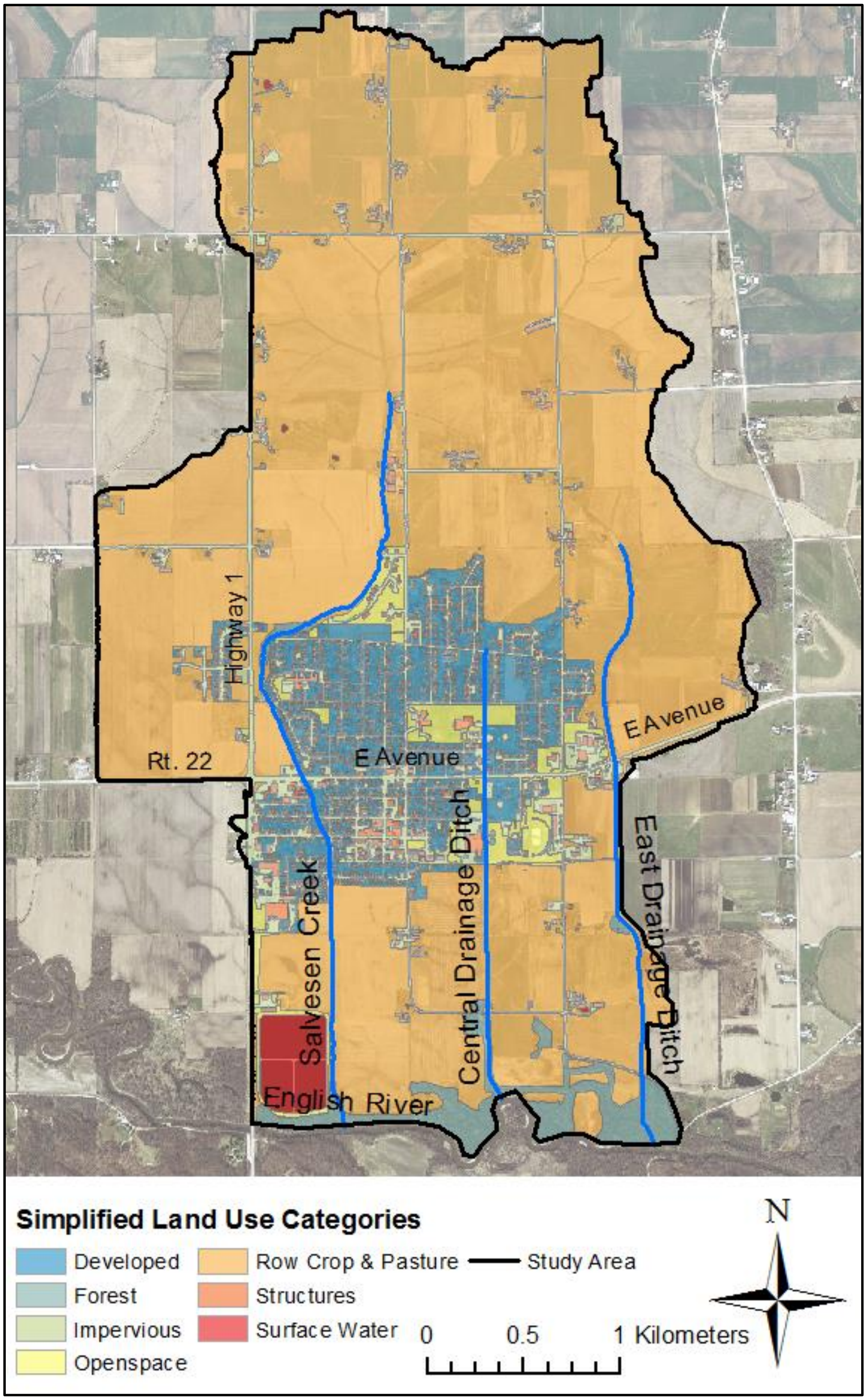


Figure 3-3: Simplified Land Use Categories

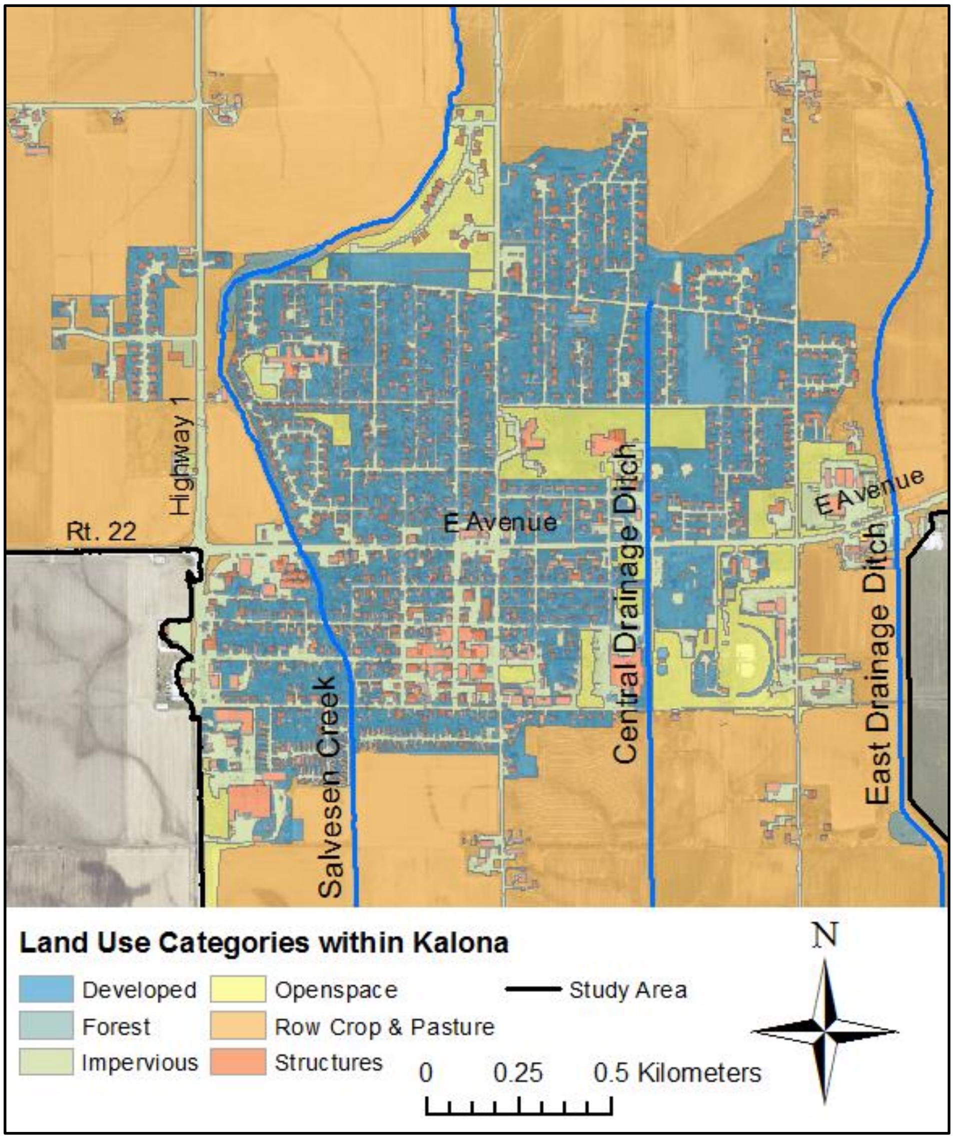


Figure 3-4: Land Use Categories for Kalona

Table 3-1: Land Use Manning's Coefficients

Category	Manning's Coefficiient
Developed	0.07
Forest	0.12
Impervious	0.015
Openspace	0.03
Row Crop & Pasture	0.035
Structures	3
Surface Water	0.02

3.5 Soil Types and Infiltration

Combining the proper soil type with land use categories was necessary to model infiltration with overland flow. The Kalona Drainage contained five classes of soil: Silty Clay Loam, Silt Loam, Loam, and Sandy Loam. As Figure 3-5 shows, the three predominant soil classes are Sandy Loam, Silt Loam, and Silty Clay Loam. Clay Loam was combined with Silty Clay Loam based on their similar parameters to simplify the land use categories. Table 3-2 shows the XPSWMM reference table for each soil category's Green-Ampt Infiltration parameters (XP Solutions 2005). The wilting point of each soil as used as the initial moisture condition (Chin 2013). Since infiltration is combined with land use categories in the model, these were combined to create 13 distinct land use categories displayed in Figure 3-6.

Table 3-2: Green Ampt Infiltration Scheme Soil Parameters

Soil Texture	Hydraulic Conductivity (mm/hr)	Wetting Front suction head (mm)	Porosity	Wilting Point
Silty Clay Loam	1	273	0.432	0.21
Clay Loam	1	208.8	0.309	0.187
Silt Loam	3.4	166.8	0.486	0.135
Loam	7.6	88.9	0.434	0.116
Sandy Loam	10.9	110.1	0.412	0.085

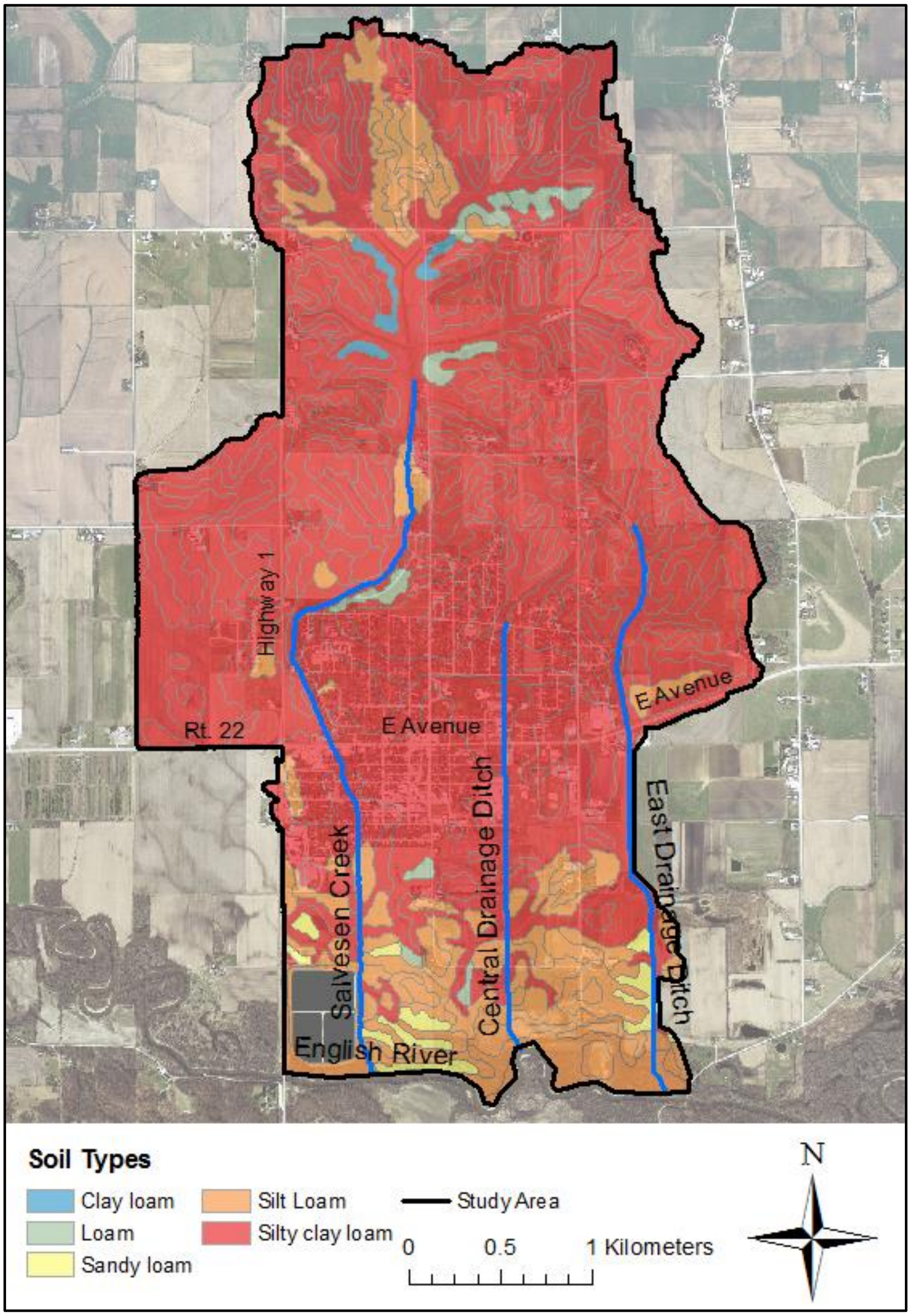


Figure 3-5: Soil Types in the Kalona Drainage

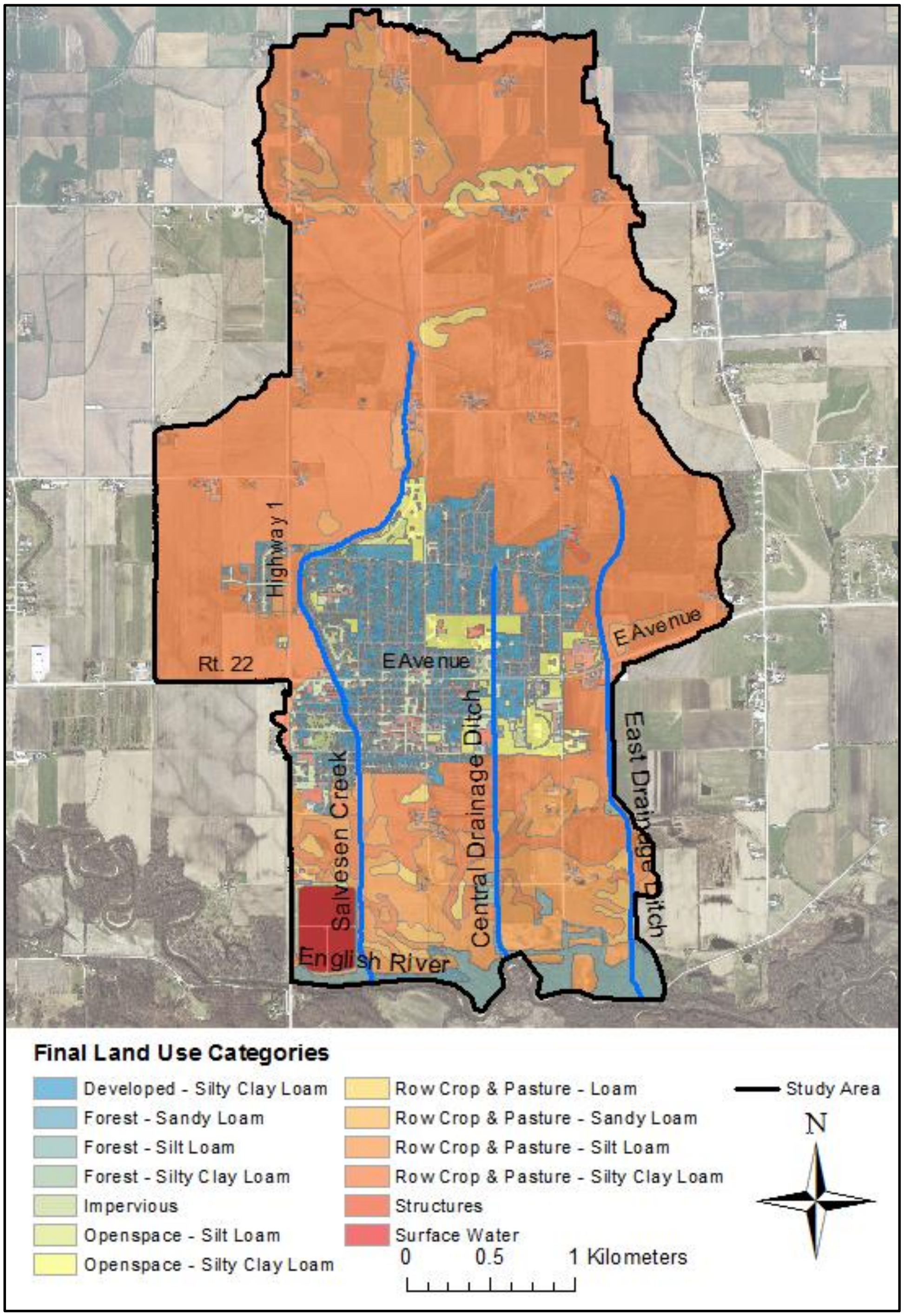


Figure 3-6: Final Land Use Categories

3.6 Mapping the Drainage Network

The cross-sections and culvert information for the Central Drainage Ditch and the East Drainage Ditch were measured using a Trimble R8 Receiver with an accuracy of ± 0.02 m vertical and ± 0.01 m horizontal (Trimble 2008). Culvert information for the each creek was collected by physical inspection. The Iowa Department of Transportation provided plan sheets for bridges over Salvesen Creek for A Avenue, C Avenue, and E Avenue (Calhoun-Burns & Associates, Inc. 1998, Calhoun-Burns & Associates, Inc. 2010). The Central Drainage Ditch and East Drainage Ditch cross sections were manually taken while the City of Kalona provided those for Salvesen Creek. In areas where a direct line was not possible due to tree cover, points were interpolated either upstream or downstream of the designated area with an assumed constant slope.

Each manhole and inlet in Kalona was mapped using the same receiving device as used for the cross sections. For rectangular grate inlets, four points were taken at each corner. In areas where this was not possible, offsets were marked for interpolation. These offsets were taken from across the street for location and up and down for elevation. The elevation was interpolated using the average slope from the offsets. In the case of vertical concrete openings in curbs, points were taken at the end of each opening and on the accompanying manhole. When the concrete manhole top was level, the point was taken near the cast iron cover. If it was not level, the point was taken on the middle of the cover's rim. The type of opening was recorded by size, orientation of opening(s), and material.

A Kalona employee made manhole measurements to be recorded by the author. The employee opened the grate or cover and used a tape measure to record the distance from the invert to the top of the manhole cover. In the case of grates, this measurement was to the lowest point to the street. If the inlet was a vertical slit, the measurement was from the top of the manhole cover to the manhole invert. The manhole bottom elevation was assumed to be constant. The employee also measured the diameter of each pipe entering and leaving the manhole. Any pipes 6” or less were ignored in the hydraulic model unless otherwise noted, as this runoff was assumed to come from building gutters and would enter the system via the streets. Numerous assumptions were made to augment missing information, such as pipe slopes, diameters, material, etc. Figure 3-7 shows the storm sewer map created from this procedure.

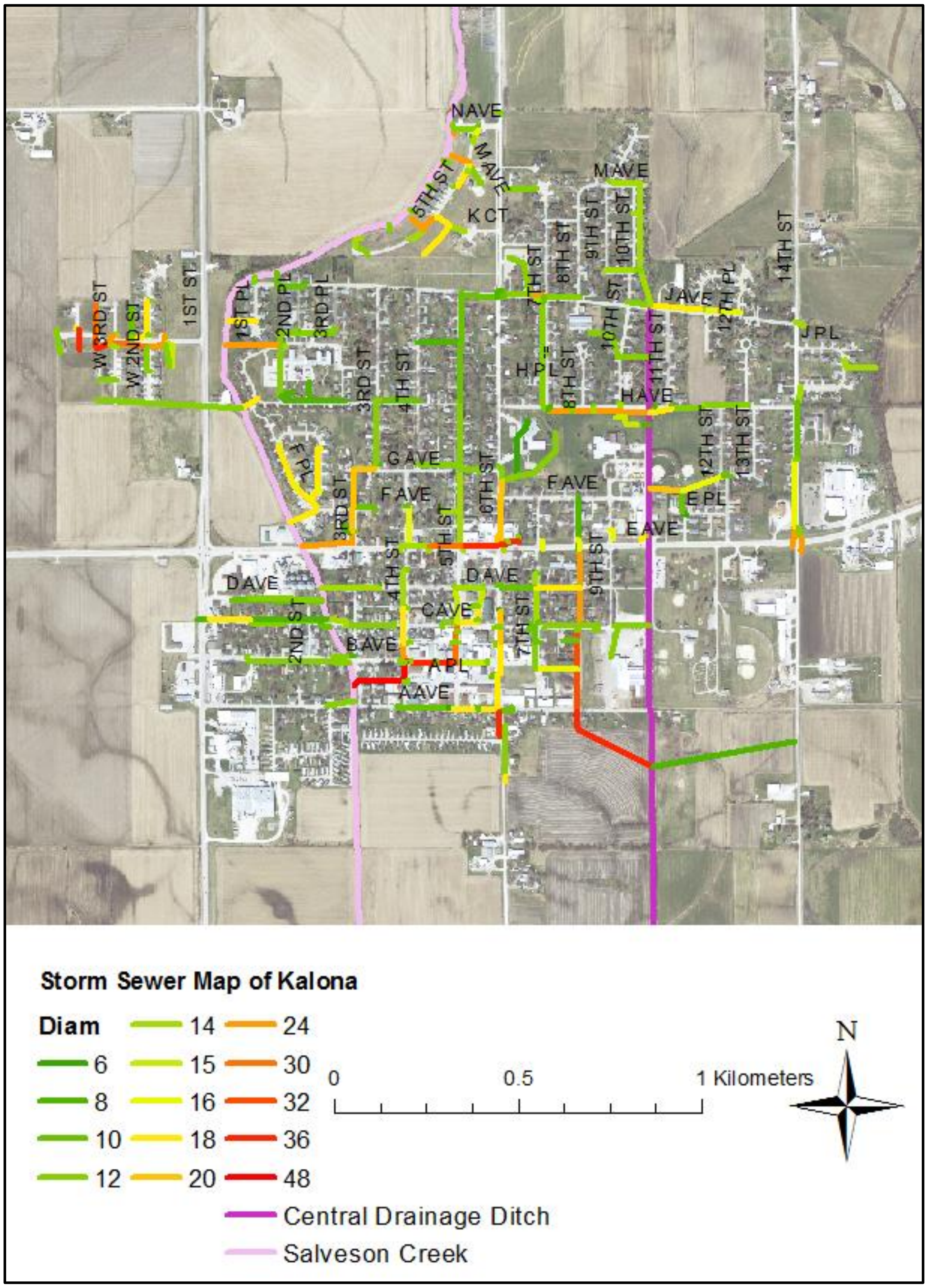


Figure 3-7: Storm Sewer Map of Kalona

Each pipe was given a conduit based on the prototype. Input parameters used in the model include pipe geometry, upstream invert, downstream invert, slope, length, and Manning’s n. Distinctions for rectangular or irregular shapes were made based upon shapes observed in the field and options provided by XPSWMM. Open channels were defined by their cross section. Station and elevation data was directly input into the model through the natural section dialog. Manning’s n was defined as 0.05, and 0.04 for the left and right banks and the main channel, respectively. APPENDIX G and APPENDIX H show the maps listing each link and node used to create the model and input parameters for each conduit, respectively.

All bridges and culverts had their barrels and openings modeled in 1D. However, due to the unusual nature of some double barrel culverts and open channels with overhead bridges, cross sectional area, top width, depth, and wetted perimeter were directly input into the model. Cross sections were developed and used to calculate the top width, flow area, and wetted perimeter for each depth. The Salvesen Creek closed conduit under E, C, B, and A Avenues and the Eastern Drainage Ditch under A Avenue were modeled using this method. APPENDIX J contains the parameters for each bridge. Culverts and bridges also had a weir flow layer to calculate flow over the road deck. This weir was used to preserve momentum over the deck and had a coefficient of 1.7. Bridge length, low chord, and high chord elevations supplied by the City of Kalona were used for Salvesen Creek weir geometries. These parameters for other bridges and culverts were either surveyed by the author or taken from the LiDAR topographic dataset.

XPSWMM models losses through bridge sections as head proportional to the velocity head gradient. Typical values were used for entrance, exit, expansion, and contraction coefficients. Table 3-3 shows the entrance loss coefficients used for bridges and culverts (Corvallis Forestry Research Community 2015). Expansion and contraction losses were set to 0.3 for bridges over Salvesen Creek, Central and East Drainage Ditches, and the E Avenue Roadside Drainage Ditch (US Army Corps of Engineers 2010). Skewness was incorporated into Salvesen Creek at E, C, and B Avenues by calculating the product of the station and the cosine of the skew angle.

Table 3-3: Entrance Loss Coefficients, Ke, for Bridges and Culverts
(Corvallis Forestry Research Community 2015)

Type of Culvert	Type of Inlet	Coefficient, Ke
Concrete Pipe Projecting from Fill (no headwall)	Square cut end	0.5
	Socket end	0.2
Concrete Pipe with Headwall and/or Wingwall	Square cut end	0.5
	Socket end	0.2
Corrugated Metal Pipe or Pipe Arch	Projecting from Fill	0.9
Box Culvert Wingwalls at 30 to 75 degrees from Barrel	Square edge at crown	0.4
Box Culvert Wingwalls at 10 to 25 degrees to Barrel	Square edge at crown	0.5

3.7 1D/2D Boundaries

At each manhole, culvert, and open stream, the 1D network was connected to the 2D grid. This was accomplished in three ways, an internal rating curve, head interface lines, and flow interface lines. Each manhole with a grate or curb opening was given a second node within the same cell connected via a “multilink”. A multilink is a type of conduit with multiple layers to measure flow between the same upstream and downstream nodes. The second node had its invert set to the grid elevation. The downstream nodes had their spill crest set to the prototype grate elevation and invert set to the lowest pipe invert. This node was “sealed,” disconnecting it from the 2D grid. An internal rating curve connected the two nodes. For grate and curb inlets on grade with curb, equations were taken from Federal Highway Administration’s Hydraulic Engineering Circular No. 22 (HEC-22) design standards (Federal Highway Administration 2009). These equations were combined with standard orifice equations, and the minimum was taken at 0.05 m head intervals. Input parameters for these equations included cross sectional slope, longitudinal slope, inlet geometry, grate type, gutter geometry, and Manning’s Coefficient. Table 3-4 shows the list of input parameter for each inlet on grade. Inlets not on grade such as circular drainage grates or beehive grates were given the minimum of weir and orifice flow equations based on their geometry. The use of inlet rating curves did not prevent surcharged flow from entering the 2D grid from the storm sewer network.

Table 3-4: Input Parameters for HEC-22 Inlet Curves

Opening Type	Length (m)	Width (m)	Height (m)	Splash Over Velocity (m/s)	Gutter Depression (mm)	Longitudional Slope (%)	Cross Sectional Slope (%)
3' X 1.5' P-50 Grate	0.914	0.457	--	3	50.8	Varies	2
3' X 2' P-50 Grate	0.914	0.61	--	3	50.8	Varies	2
3' X 1.5' 45 Degree Tilt Grate	0.914	0.457	--	2	50.8	Varies	2
4' Curb Inlet	1.219	0.61	0.152	--	152.4	Varies	2
9' Curb Inlet	2.743	0.61	0.152	--	152.4	Varies	2

Head interface lines separated open channels from the 2D grid. These lines were also linked to the boundaries of the inactive areas over the banks of the channels. Open channels were modeled as inactive in the 2D grid to avoid double conveyance. The head interface lines allowed flow to move freely between the 2D grid and the open channels at each boundary cell. If the head in an adjacent cell was greater than that in the channel, then the flow from the cell into the open channel would be added to the closest node. If the head in the channel was greater than the cell, then the head in the cell would increase to that of the channel, with the flow subtracted from the closest node. Each open channel had a spill crest linked to the 2D grid. The elevation of the spill crest represented the maximum value of head in the channel. This was deliberately set higher than any flood could go to allow for a horizontal head value across the floodplain.

Bridges and culverts without a one dimensional channel had their upstream/downstream node inverts set to the 2D grid. This allowed for the head in the cell to become the head in the node. If the culvert or bridge opening was larger than the 4 m cell size, then a flow interface line was created. This line allowed flow to equally enter or exit the 1D culvert/bridge across multiple cells. No connection between the 1D and 2D domains preserved momentum.

APPENDIX I shows the input parameters for each node. The coordinate system was North American Datum 1983 UTM Zone 15 North. The connection to the grid lists the condition which allowed flow to transfer between the 1D and 2D domains. If the node represented a manhole, then this included the geometry of the intake. “Invert” describes a node which uses the head of water at the cell as the head in the node with the invert elevation being the same as the grid. “Open” describes a natural channel with 1D/2D flow interface lines, and “default” nodes use the default XPSWMM transition equation. The surface slope for the HEC-22 equations are also listed.

3.8 Input Rainfall

10 design storms were used to create the model. The cumulative rainfall for the 1, 2, 5, 10, 25, 50, 100, 200, 500, and 1000 year storms was taken from the NOAA Atlas 14 (National Oceanographic and Atmospheric Administration 2014). 3 hour design storms were chosen because this corresponds to the length of the time of concentration for the watershed (IIHR - Hydroscience & Engineering 2014). Figure 3-8 shows the distribution for a first-quantile, 3 hour storm at a point (Huff 1992). The 10, 25, 50, 100, and 500 year storms were used to test the flood mitigation techniques, similar to previous studies testing the effects of agricultural detention basins (Iowa Flood Center 2014). Figure 3-9 shows the rainfall hyetographs using the Huff & Angel distribution for the 10, 25, 50, 100, and 500 year storms. This scheme was chosen because it had scenarios created for the 6 hour or less design storms. Rainfall is input via a “rainfall on grid” approach. Rainfall is input onto each cell, simulating the desired event. The 10 year storm was

considered the low flood event, while the 100 and 500 year storms were considered the high flood events.

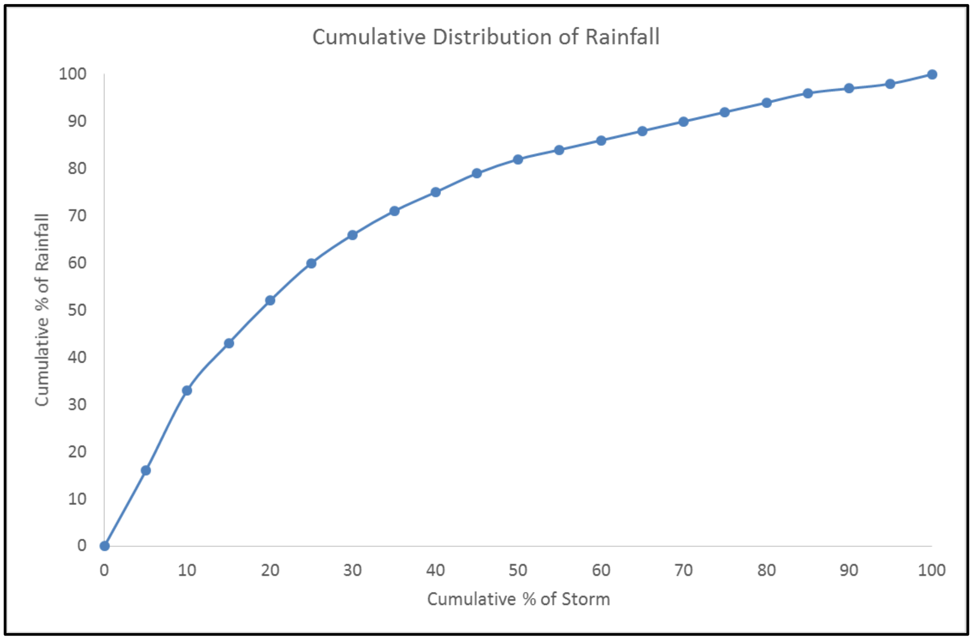


Figure 3-8: Cumulative Distribution of Rainfall

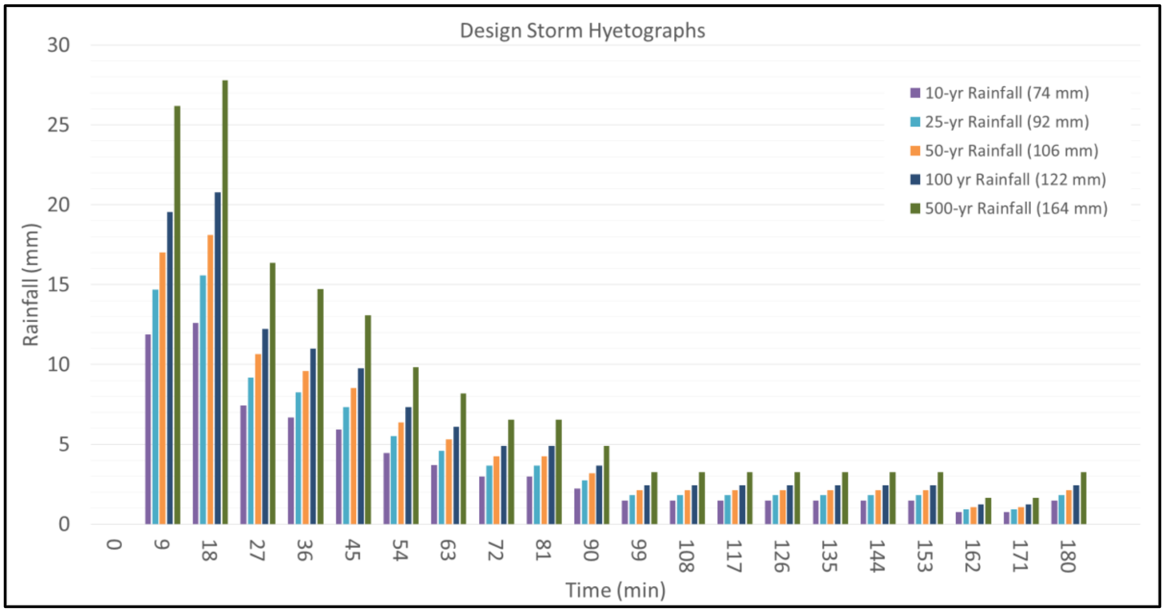


Figure 3-9: Design Storm Hyetographs

3.9 Downstream Boundary Conditions

Three 1D and 11 2D head boundary conditions were used to control flow leaving the model. The first 2D head boundary condition was placed to the south and west of the Harvest Hill neighborhood on the west side of Highway 1. The head boundary condition was set to below the cell elevation. This allowed runoff which was not captured by the local detention basin or infiltrated into the ground to freely flow off of the model since it would not contribute to the Kalona Drainage.

Ten 2D head boundary lines directly north of the English River allowed flow to leave the 2D grid and formed a continuous boundary at equal spaces to simulate river elevation. However, for stability purposes, the 2D boundary did not include the English River itself, and ended just north, or upstream in the Kalona Drainage. Each stream had a 1D link with one node inside and outside of the 2D domain. This improved model stability by simulating the streams draining into the English River without flow reentering the 2D model. A constant elevation for the English River stage was entered into each 2D head boundary and 1D stream to simulate flooding and backwater effects along the English River. The flows in the English River and runoff from the Kalona Drainage were assumed to be independent.

A coincident flow analysis was performed using HEC-SSP to calculate the English River stage most associated with the Kalona Drainage runoff (US Army Corps of Engineers 2010). First, the XPSWMM model calculated the maximum runoff from the entire Kalona Drainage into the English River for each design storm. Figure 3-10 shows the log plot for each return period and Figure 3-11 shows the discharge exceedance probabilities.

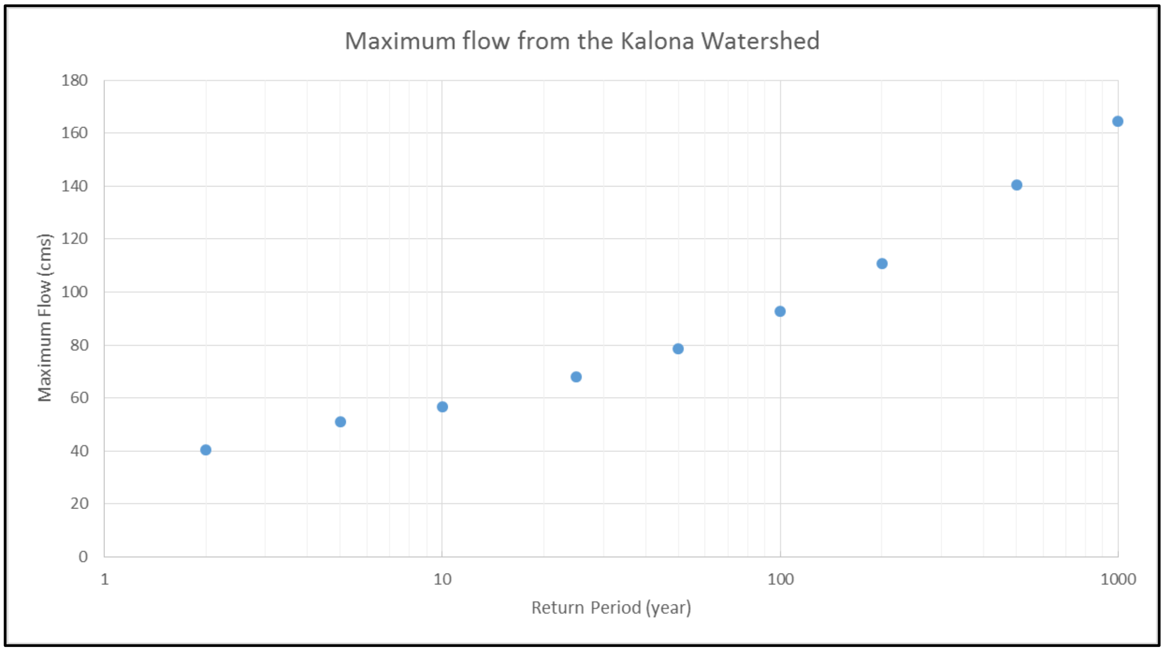


Figure 3-10: Peak Flows from the Kalona Drainage

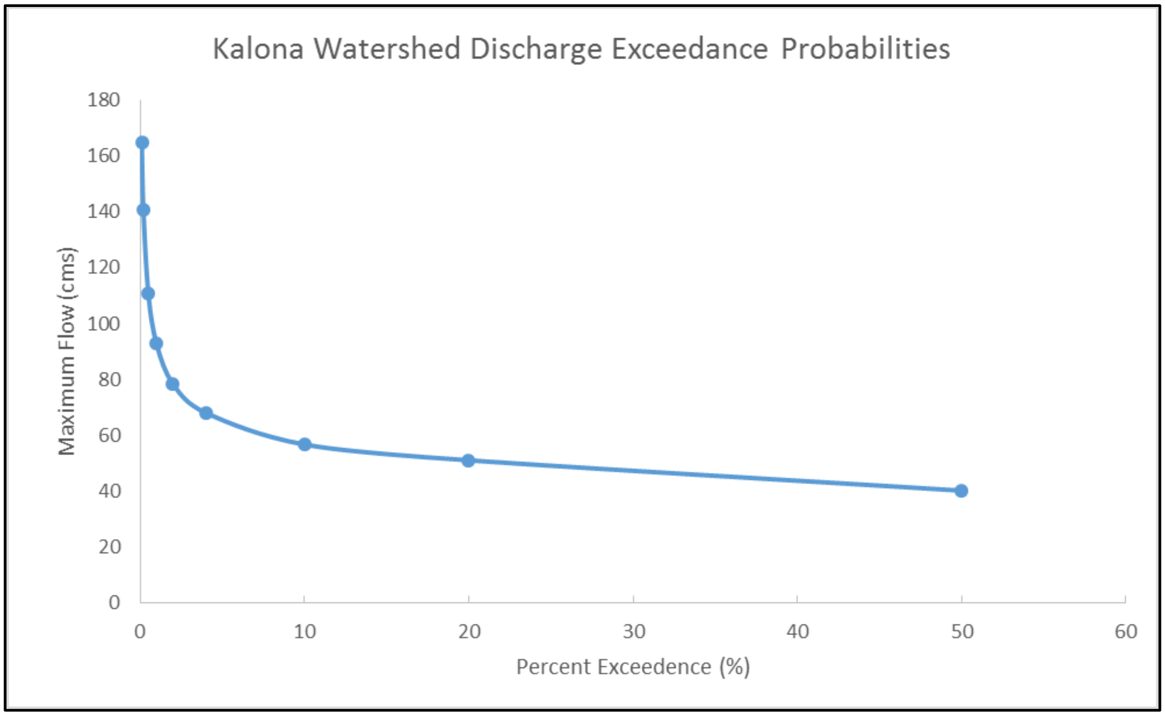


Figure 3-11: Kalona Drainage Duration Curve

A duration curve was used to calculate exceedance probabilities for English River discharge. USGS stream gauge 05455500 recorded mean daily discharges from September 1939 until the date of retrieval, July 2015, under Highway 1 just upstream of the confluence of Salvesen Creek and the river (US Geological Survey 2015).

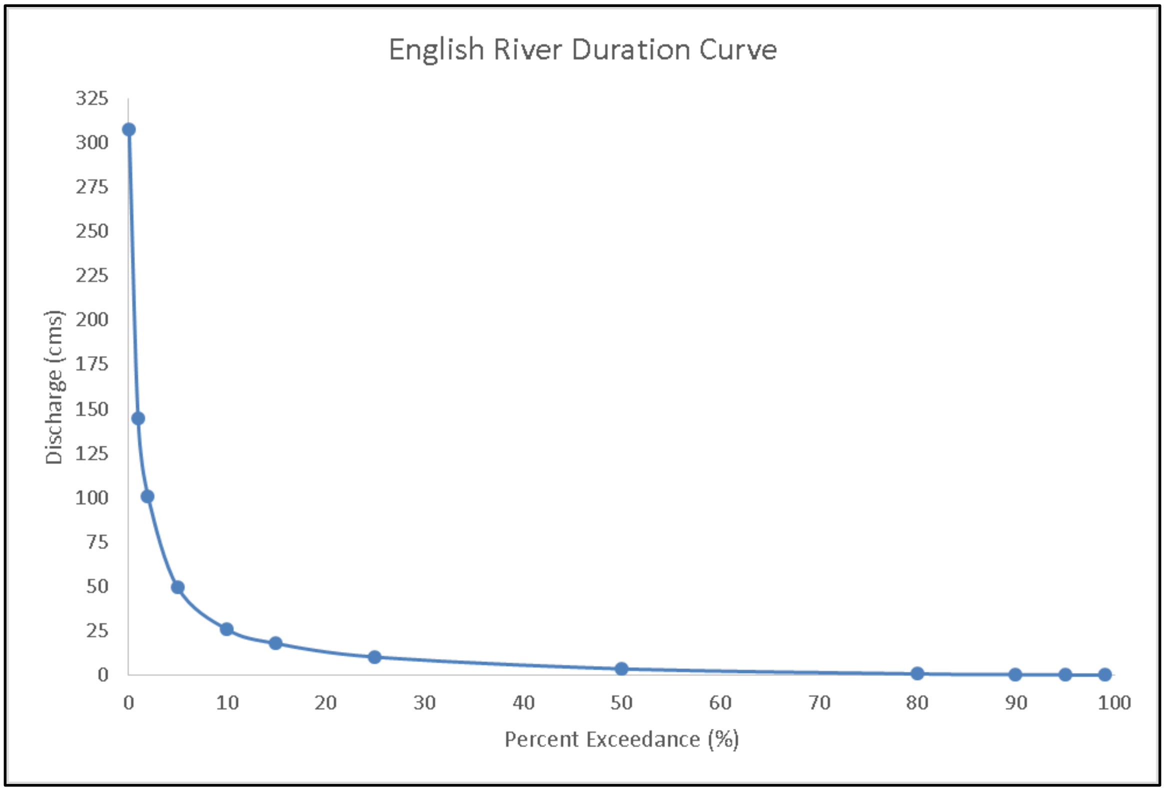


Figure 3-12: Duration Curve for the English River at Kalona

The Kalona Drainage runoff for return periods 2 years through 1000 years, 3 hour storms were combined with 9 index values from the English River duration curve. An English River stage-discharge relationship was created using 15 minute interval data from April 2013 to July 2015 at the Kalona gauge (US Geological Survey 2015). English River discharges for each index point were added to peak Kalona Drainage runoff flows to create 9 total English River discharges for each storm. The English River stage-discharge relationship was used to calculate its stage given the 9 flow rates for each of the 9 storms. Stages for each index point were then compared to the Kalona Drainage storms by response curves. Figure 3-13 shows these response curves giving the relationship between English River stage and Kalona Drainage storm.

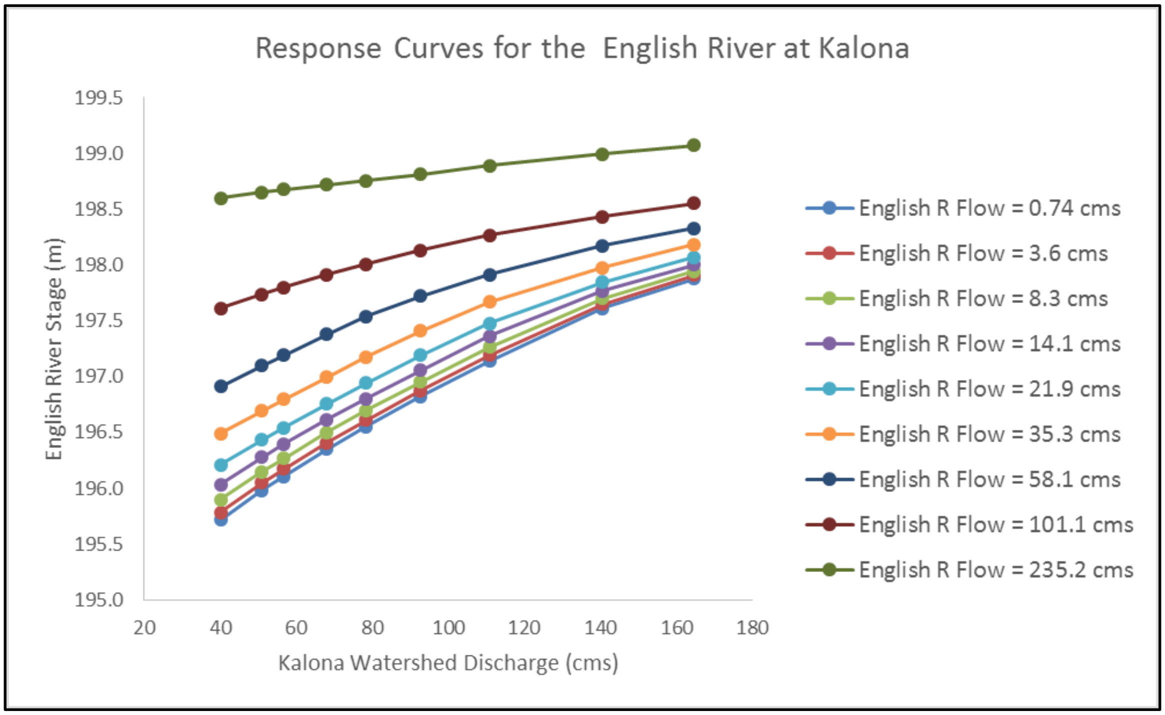


Figure 3-13: Response Curves for the English River at Kalona

To create the coincident frequency analysis, HEC-SSP calculated an exceedance curve from the peak Kalona Drainage runoff discharges. Then it assigned a frequency of exceedance value to each stage from the response curves. Using 20 evenly spaced English River stages from the minimum of 195.34 meters to the maximum of 198.97 meters, it created a look-up exceedance frequency value. It multiplied this value by the related proportion of time for each index point. These products were added together to form a weighted average for each Kalona Drainage storm (US Army Corps of Engineers 2010). Figure 3-14 shows the resultant English River stage. APPENDIX K shows lists the values input into the model.

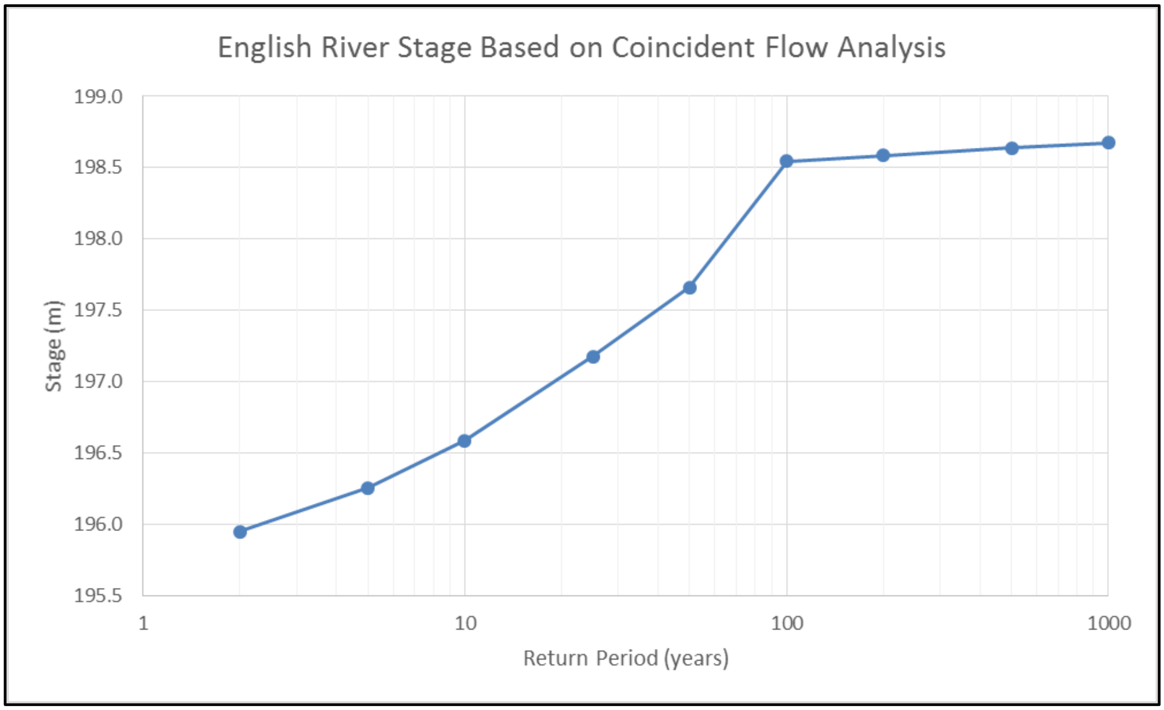


Figure 3-14: English River Stage Based on Coincident Flow Analysis

3.10 Model Confirmation

Two meetings were held with officials from the City of Kalona and the English River Watershed Management Authority to confirm that the model's results were representative of their experiences. This was necessary because no data was available to calibrate the model. The first meeting was held on August 11th, 2015, and included the author, Kalona City Administrator and the English River WMA Chair Ryan Schlabaugh and the English River WMA Watershed Coordinator, Jody Bailey. The second meeting was held with the Kalona City Council on August 17th, 2015, and included the author, Ryan Schlabaugh, the entire city council, mayor, and Dr. Nathan Young of IIHR-Hydroscience & Engineering. Maps of the 10, 25, 50, 100, 500, and 1000 year, and observed storms were presented at both meetings, along with animations showing flood patterns. The officials confirmed that the model was performing adequately based on previous experiences and complaints from local residents. Specifically, flooding in the softball fields, east of downtown, Pleasant View Circle, and 1st Place were signaled out as accurate. However, official data on peak water depths or discharges was unavailable.

The performance and stability of the model used for this thesis were confirmed by comparing results against the previous MIKE 11/21 coupled 1D/2D model of Salvesen Creek (IIHR - Hydroscience & Engineering 2014). MIKE 11 was the one dimensional solver, while MIKE 21 was the two dimensional solver. HEC-HMS was used to model the Salvesen Creek watershed. Figure 3-15 shows the watershed catchments and creek for this model. First, hyetographs were produced for the 2, 5, 10, 25, 50, 100, 200, and 500 year rainfall events using the National Oceanic and Atmospheric Administration's Atlas 14 Volume 8 and the Rainfall Frequency Atlas of the Midwest (National Oceanographic and Atmospheric Administration 2014, Huff 1992). SCS Curve Numbers for each basin within the watershed calculated the initial abstraction and continuing loss for infiltration. The Muskingum method routed flow through the creek.

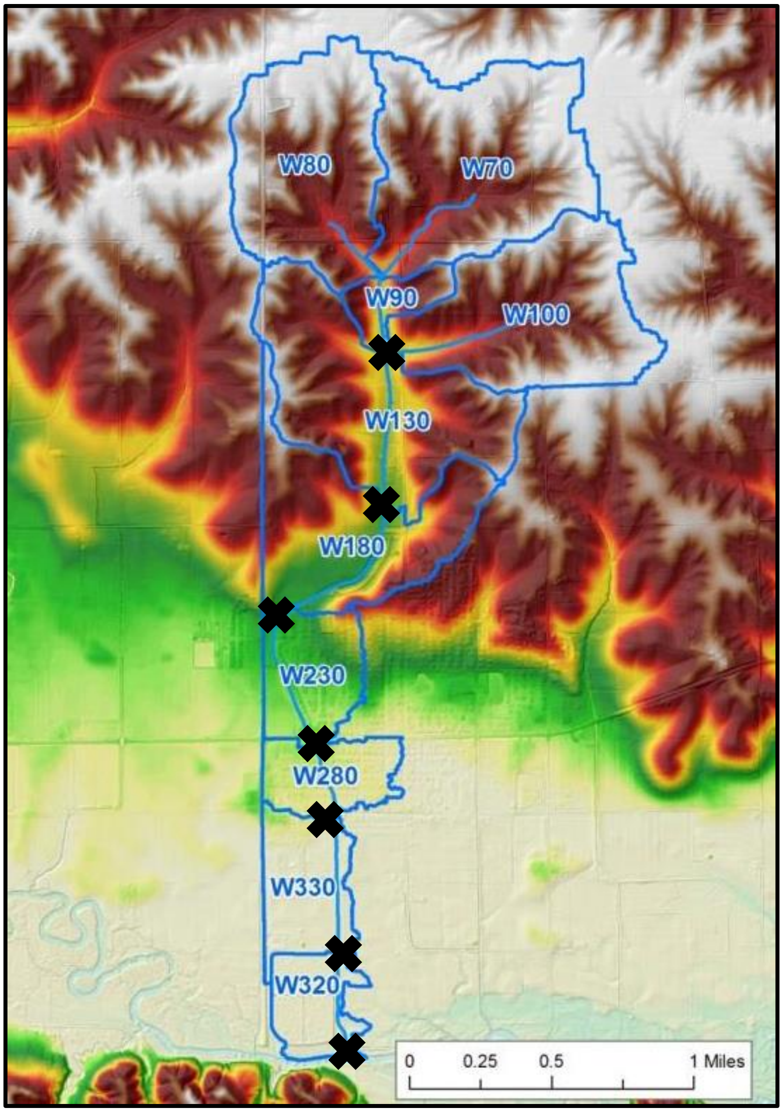


Figure 3-15: Salvesen Creek Watershed as Modeled Using HEC-HMS (IIHR - Hydroscience & Engineering 2014)

The HEC-HMS runoff hydrographs from each catchment were input into the one dimensional MIKE 11 Salvesen Creek with the assumption that flooding within Kalona resulted from creek overflow. These same HEC-HMS inputs were used at comparable locations along the creek in the XPSWMM model. These locations are demarcated with an X. The runoff from W100, W90, W80, and W70 were combined because the one dimensional XPSWMM Salvesen Creek started near the W90 outlet.

Several aspects of the XPSWMM model were altered to better replicate the previous model. First, the XPSWMM 1D storm sewer network was deactivated, as were the one dimensional Central Drainage Ditch and the East Drainage Ditch because they were not included in MIKE11/21 model. Instead, these creeks were modeled using the 2D grid. MIKE 11 used a modified WSPRO method to calculate flow through the E Avenue Bridge and C Avenue, B Avenue, and A Avenue culverts (Federal Highway Administration 1998, DHI 2013, DHI 2013). Since XPSWMM simulates the entire 1D network with XTRAN, the equations used to calculate head loss and flow through a submerged bridge were different. Therefore, head losses through the XPSWMM bridge and culvert sections were calibrated using entrance and exit loss coefficients. 0.7 was added to the entrance and exit loss coefficients for the E, C, B, and A Avenue bridges to equate the head losses. Salvesen Creek water surface elevations and floodplain inundated areas were compared to validate the performance of the XPSWMM model.

The MIKE 21 model used a 5 meter grid cell size and land use data from the 2006 National Land Cover Dataset. Both MIKE 11/21 and XPSWMM used the one dimensional and two dimensional St. Venant equations and the alternating direction implicit scheme solver (IIHR - Hydroscience & Engineering 2014). Minor deviations between the models were expected due to the different grid cell sizes, one dimensional and two dimensional interfaces, and land use covers.

Figure 3-16 shows the water surface profile for Salvesen Creek comparing MIKE 11 to XPSWMM. Figure 3-17 and Figure 3-18 show the inundation maps for Kalona with the HEC-HMS inputs into the Salvesen Creek MIKE 11 and XPSWMM models for a low flood, 25 year event, respectively. Figure 3-19 and Figure 3-20 show the inundation maps for Kalona with the HEC-HMS inputs into Salvesen Creek MIKE 11 and XPSWMM for a high flood, 100 year event, respectively. APPENDIX A contains the MIKE 11/21 and XPSWMM maps using HEC-HMS inputs for the 50 year and 500 year storms. Two index points were chosen to compare the performance between MIKE 11/21 and XPSWMM, at the intersection of E Avenue and 4th Street and to the east of City Hall. These points were chosen because one or both are inundated during the 25 year, 50 year, 100 year, and 500 year storms, they are prominent areas in the community, and both have a significant depth of water.

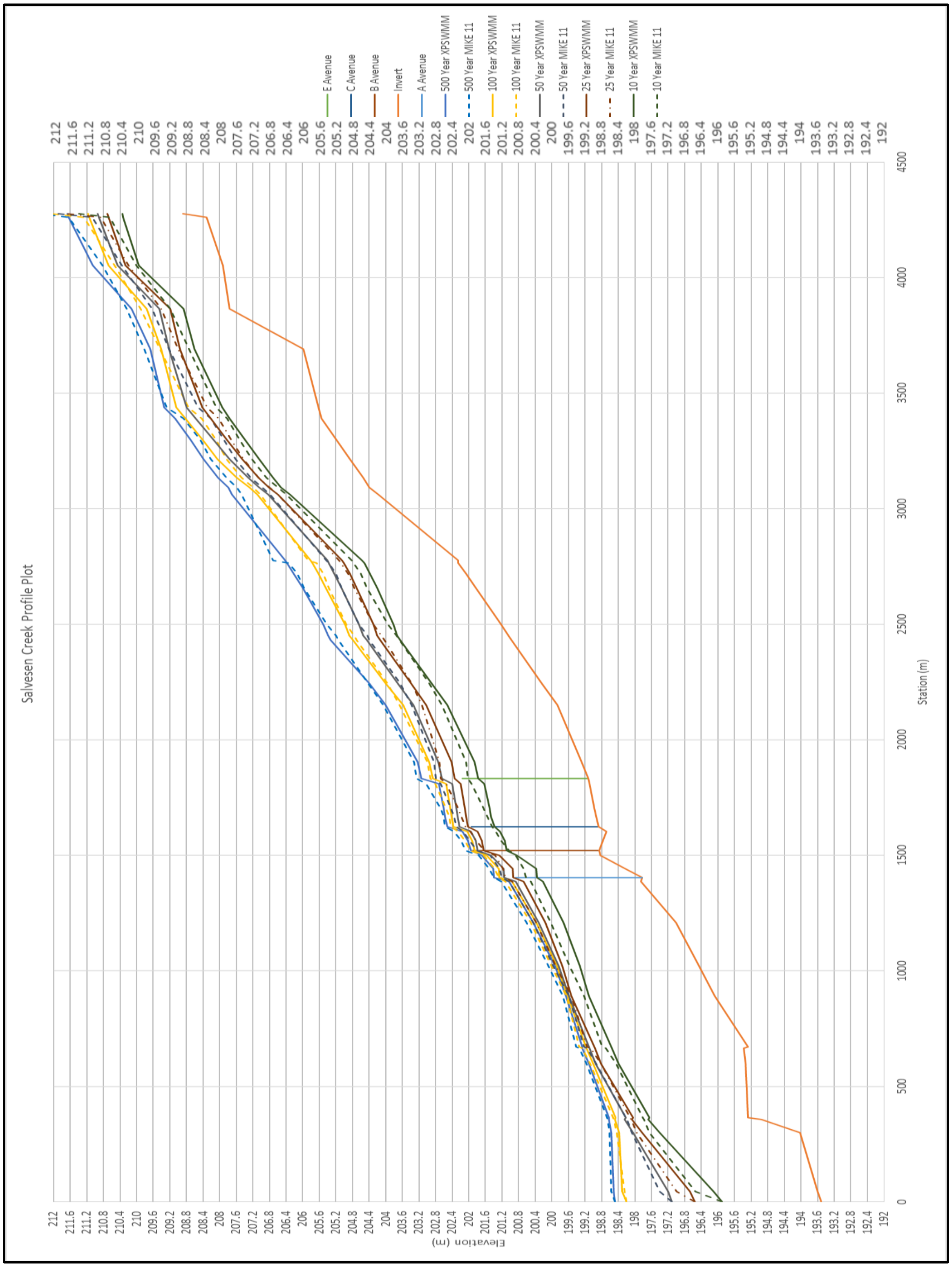


Figure 3-16: Water Surface Elevations of the MIKE 11
and XPSWMM Salveson Creek models

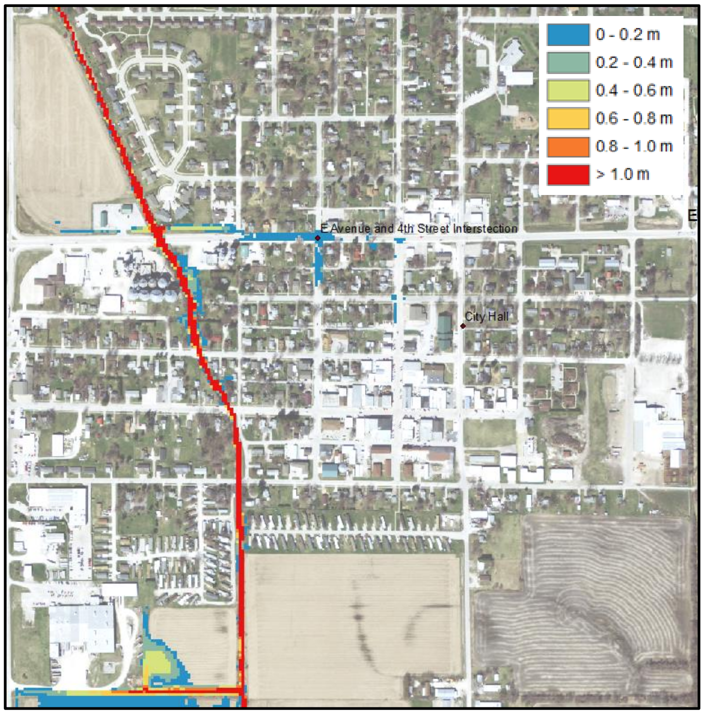


Figure 3-17: MIKE 11/21 with HEC-HMS Inputs 25 Year (92 mm) Storm Inundation Map

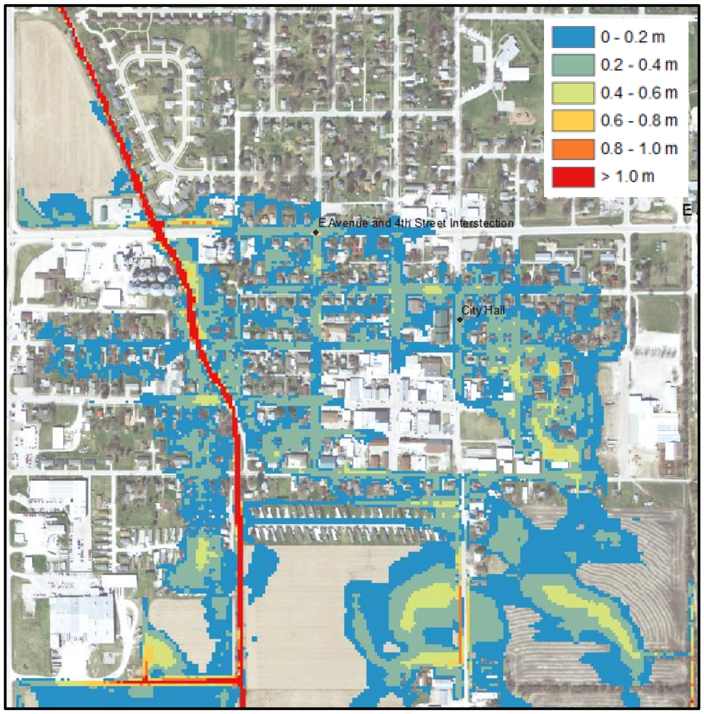


Figure 3-18: XPSWMM with HEC-HMS Inputs 25 Year (92 mm) Storm Inundation Map

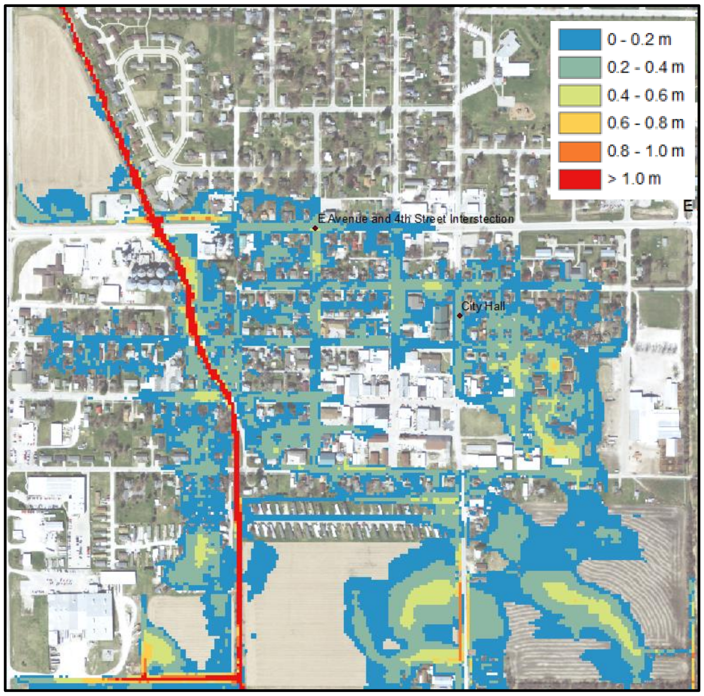


Figure 3-19: MIKE 11/21 with HEC-HMS
Inputs 100 Year (122 mm) Storm Inundation Map

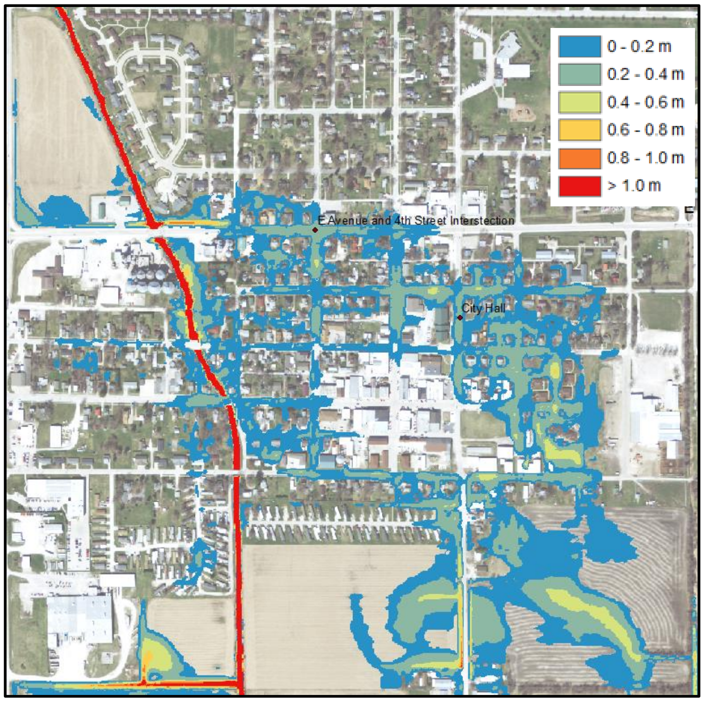


Figure 3-20: XPSWMM with HEC-HMS
Inputs 100 Year (122 mm) Storm Inundation Map

Table 3-5, Table 3-6, and Table 3-7 show the MIKE 21 model's depths at each index point, the XPSWMM model's depths at each index point, and the difference between them, respectively. The largest difference between the two models was 10.6 % at the E Avenue and 4th Street intersection during the 25 year storm. During the high intensity storms, the models showed comparable results, with less than an 8% difference during the 50 year storm, and less than 4% during the 100 and 500 year storms. The low relative difference between the XPSWMM and MIKE 11/21 inundation areas, water surface profiles, and depths at two index points showed that the XPSWMM model was performing as expected and was deemed adequate for simulating Kalona and possible flood mitigation techniques.

Table 3-5: MIKE 21 Depths with HEC-HMS Inputs

MIKE 21 Maximum Depth (m)					
Index Point	10 Year Storm Depth (74 mm)	25 Year Storm Depth (92 mm)	50 Year Storm Depth (106 mm)	100 Year Storm Depth (122 mm)	500 Year Storm Depth (164 mm)
E Avenue and 4th Street Intersection	--	0.131	0.271	0.354	0.536
City Hall	--	--	0.197	0.281	0.425

Table 3-6: XPSWMM Depths with HEC-HMS Inputs

XPSWMM Maximum Depth (m)					
Index Point	10 Year Storm Depth (74 mm)	25 Year Storm Depth (92 mm)	50 Year Storm Depth (106 mm)	100 Year Storm Depth (122 mm)	500 Year Storm Depth (164 mm)
E Avenue and 4th Street Intersection	--	0.145	0.257	0.346	0.515
City Hall	--	0.085	0.212	0.274	0.409

Table 3-7: Comparison between MIKE 21 and XPSWMM Depths with HEC-HMS Inputs

Percent Difference Between MIKE 21 and XPSWMM					
Index Point	10 Year Storm (74 mm)	25 Year Storm (92 mm)	50 Year Storm (106 mm)	100 Year Storm (122 mm)	500 Year Storm (164 mm)
E Avenue and 4th Street Intersection	--	-10.6%	5.1%	2.2%	3.8%
City Hall	--	--	-7.6%	2.5%	3.8%

CHAPTER 4. BASE MODEL, *IN SITU* MODIFICATIONS, UPSTREAM DETENTION BASINS, AND COMBINED TECHNIQUES

4.1 Chapter Introduction

This chapter presents the model results for the following scenarios: base (as it currently is), *in situ* storm sewer modifications, upstream agricultural detention ponds, and the combined mitigation strategies. It discusses the assumptions made during the process and how each technique was simulated. Using total inundation and flood reduction maps, it presents a broad overview of each techniques' effects on flooding, and it analyzes benefits and drawbacks of the mitigation strategies at three specific index points within Kalona. The storm sewer network's performance was also analyzed with each technique to determine its effectiveness.

4.2 Base Models and Flood Patterns

The base models show that both overflow from each creek and local runoff contribute to flooding. Runoff flows west down J Avenue and combines with Salvesen Creek overflow to inundate 1st Place. This water then flows south and combines with westward runoff from Pleasant View Circle. Runoff from Sharon Hill Cemetery and between 3rd Street to 6th Street flows south, inundating backyards between 3rd Street and 4th Street, 4th Street and 5th Street, and 5th Street and 6th Street. This water combines with runoff from north of H Avenue and west of 10th Street, which flows through the area between Kalona Elementary School and Mid-Prairie Middle School. Additional runoff from the F Place neighborhood joins the stream down 5th Street and 6th Street. Salvesen

Creek overflow at E Avenue runs both east and west, inundating farmland northwest of the bridge and flows east along E Avenue to 4th Street. At 4th Street, this overflow combines with runoff and flows northwest to southeast, looping around downtown and inundating the area between A Avenue to E Avenue, 4th Street to 9th Street. The area west of downtown between A Avenue and E Avenue on both sides of Salvesen Creek experiences overflow flooding as well.

Runoff from the Central Drainage Ditch overwhelms the buried pipe at H Avenue and the detention basin just south east of H Avenue and continues south. This flow merges with East Drainage Ditch overflow from the E Avenue culvert and local runoff from the Farmers Supply Sales Inc, parking lot and the neighborhoods between the Central Drainage Ditch and 14th Street to inundate homes west of 12th Street. This flow then crosses E Avenue and drains back into the Central Drainage Ditch either immediately or after crossing Kalona City Park. Figure 4-1 displays the flow routes.

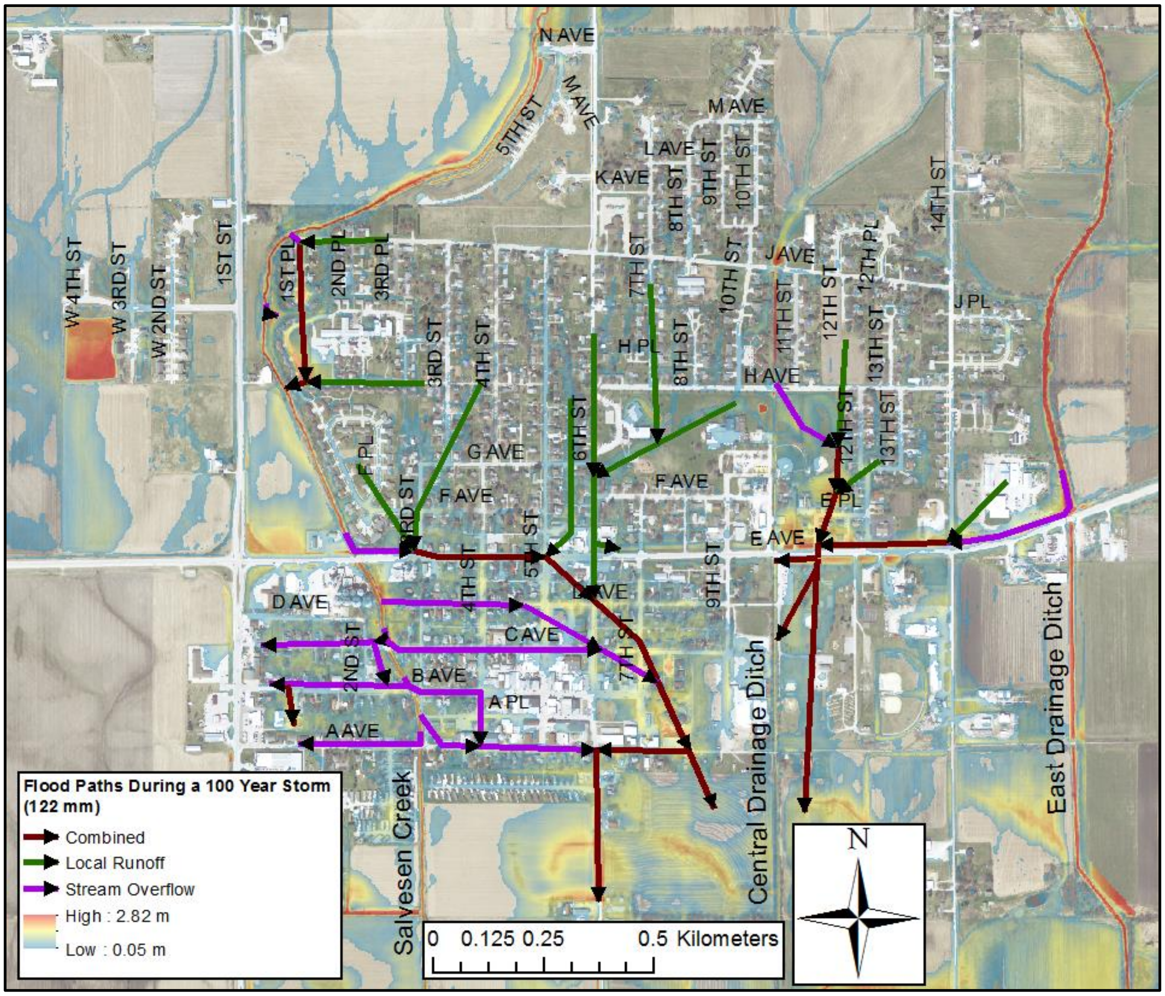


Figure 4-1: Flood Paths during a 100 Year Storm (122 mm)

Figure 4-2, Figure 4-3, and Figure 4-4 show the base inundation maps for the 10 year, 100 year, and 500 year storms, respectively. These were chosen to represent the low flood and high flood conditions. APPENDIX B shows the 25 year and 50 year storms maximum depth maps. During low flood conditions, minor flooding occurs in the 1st Place, Pleasant View, F Place, and the E Place neighborhoods. More extensive flooding occurs to the area east of downtown. Index points were chosen at Pleasant View Circle, City Hall, and in the Softball Practice Area south of the softball fields. These were selected to represent specific areas of extensive flooding and are also common areas for the community to determine the effectiveness of the mitigation techniques.

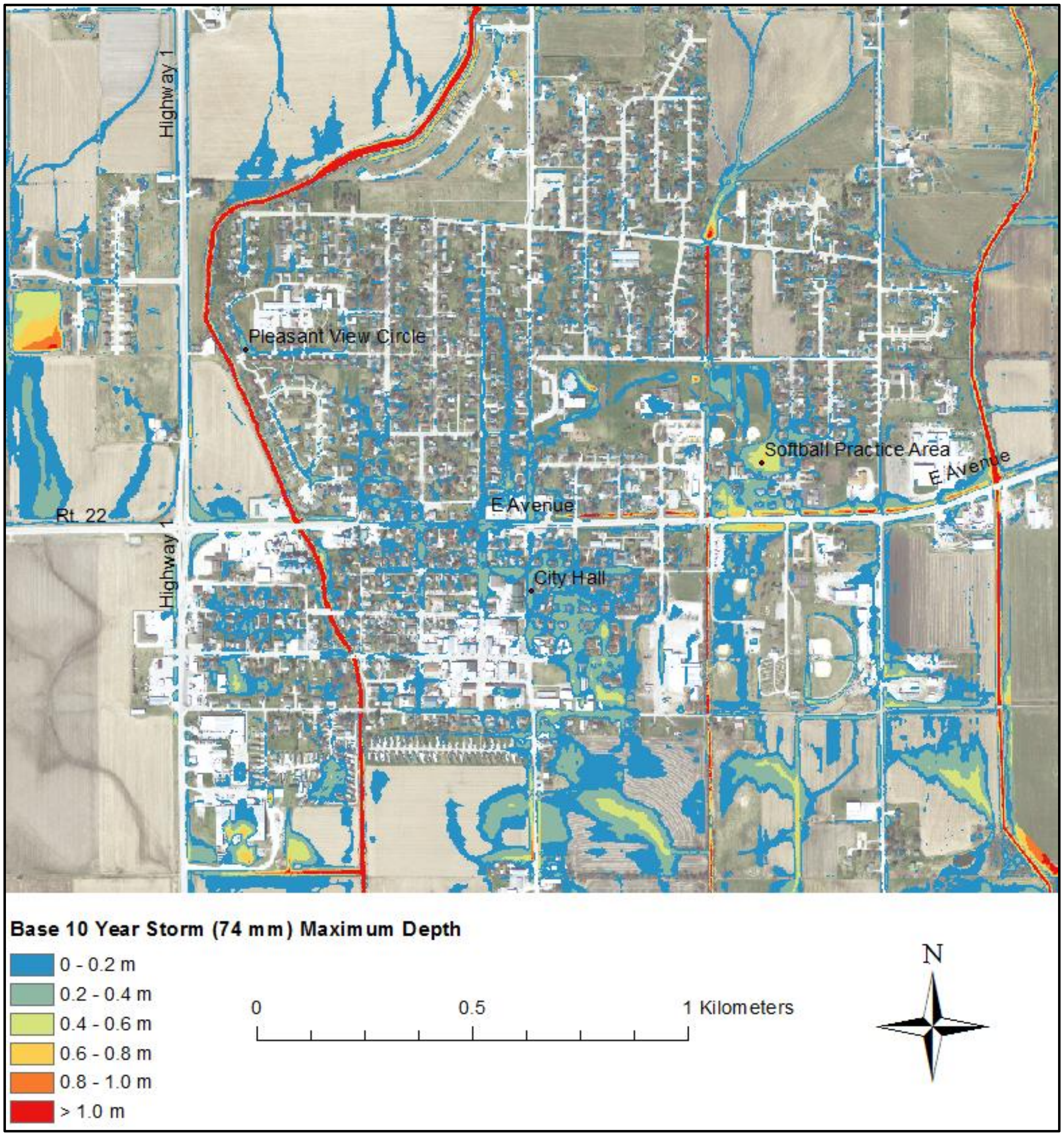


Figure 4-2: Maximum Depth for a Base 10 Year (74 mm) Storm

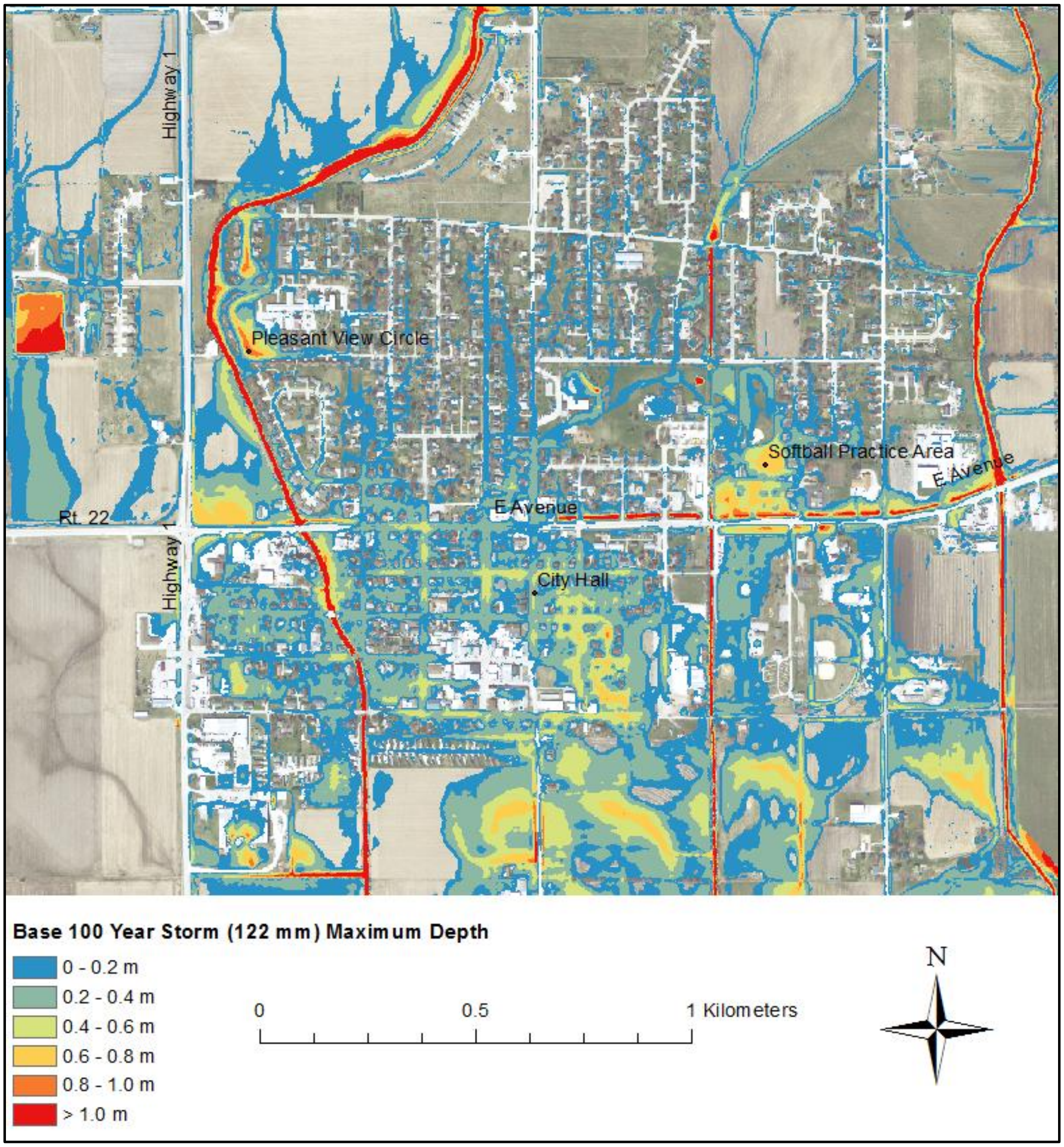


Figure 4-3: Maximum Depth for a Base 100 Year (122 mm) Storm

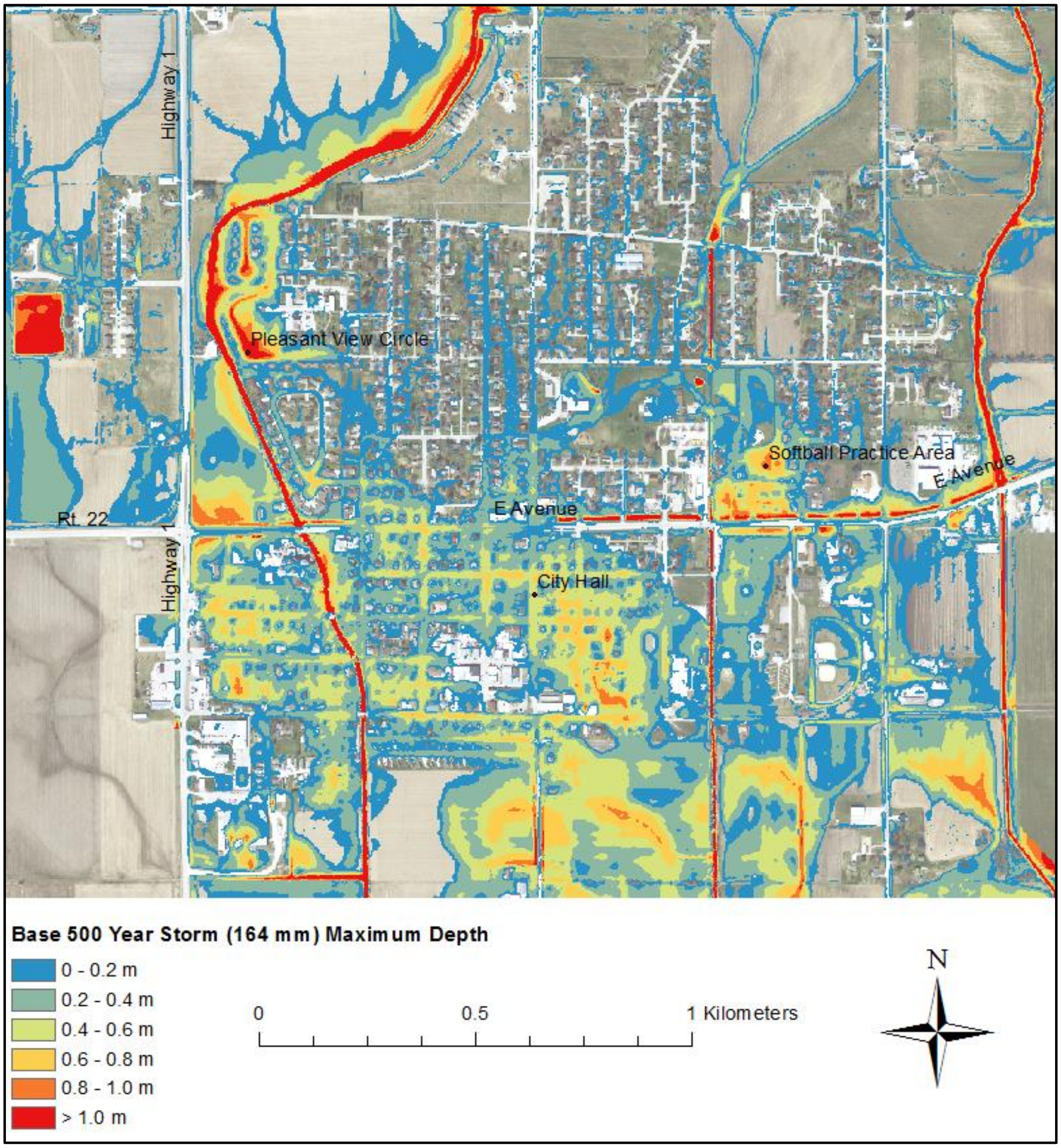


Figure 4-4: Maximum Depth for a Base 500 Year (164 mm) Storm

Table 4-1 displays the maximum depths at each index point. These depths were used for comparing the mitigation strategies. Each index point experienced an increase in depth due to each successive storm. However, Pleasant View Circle experienced a much greater increase, 1.01 meters between the 10 year and 500 year storms, compared to 0.25 meters and 0.3 meters for the Softball Practice Area and City Hall, respectively.

Table 4-1: Maximum Depths for the Base Model

Base Model Maximum Depth (m)					
Index Point	10 Year Storm Depth (74 mm)	25 Year Storm Depth (92 mm)	50 Year Storm Depth (106 mm)	100 Year Storm Depth (122 mm)	500 Year Storm Depth (164 mm)
Pleasant View Circle	0.35	0.65	0.87	1.03	1.36
Softball Practice Area	0.62	0.70	0.75	0.79	0.87
City Hall	0.24	0.28	0.33	0.40	0.54

Table 4-2 shows the performance of the storm sewer network for the base model. For each storm of increasing intensity, additional pipes were at over capacity. Capacity was defined as the calculated flow divided by the design flow. If a pipe was surcharged at the upstream end, then it was modeled as pressurized. Design flow is the maximum flow calculated via the Manning's equation. The majority of pipes at over capacity drained directly into the streams or are concentrated in the flat lying areas of town south of E Avenue. Even though a pipe may be under capacity, it can still flow full if back flow conditions prevent the pipe from being fully utilized.

Table 4-2: Base Model Storm Sewer Performance

Base Storm Sewer Network Performance		
Storm	Manholes Flooded	Storm Sewers at Over - Capacity
10 Year (74 mm)	52%	29%
25 Year (92 mm)	59%	33%
50 Year (106 mm)	63%	36%
100 Year (122 mm)	65%	38%
500 Year (164 mm)	73%	44%

Overall, the storm sewer network was ineffective for two reasons: pipes were overloaded even for the low flood event and backflow from the creeks reduced the effectiveness of pipes with excess capacity. The amount of over-capacity sections in the network shows how portions were performed at less than the 10 year storm. This could be because the shallow elevation gradient prevented adequate pipe slopes, the minimum cover between the road and the pipe's crown prevented large enough diameters, and sections of the network could have been designed without future developments in mind. Furthermore, backflow from the streams prevented pipes from draining at full capacity. Even if a pipe was adequately sized for a certain event, a proper head gradient between the upstream manhole and outlet would decrease the maximum flow.

4.3 *In Situ* Flood Mitigation Strategies

Flood mitigation strategies were divided into distributed storage north of Kalona and *in situ* techniques within the town. The division was necessary to give stakeholders an accurate assessment of how best to manage costs, risks, and benefits. For example, if planners decided that upstream distributed storage was too risky in case of embankment failure, then they would know how other improvements could mitigate flooding.

Modifications to the storm sewer network included pipe and inlet resizing, pipe additions, invert relocations, drainage ditch cross section changes, and installation of back flow valves. According to the Iowa Storm Water Management Manual, the minimum cover allowed between the crown of a drainage pipe and bottom of concrete pavement is 1 foot (Iowa Department of Natural Resources 2010).

Techniques were tested using the 10 and 25 year storms to determine their effectiveness. If they resulted in noticeable areas with water depth reduction greater than 5 centimeters, then they were included in the modifications recommendation. If they did not result in peak depth reductions, then they were not included. Examples of strategies which did not significantly reduce flooding include downstream pump stations and tidal gates, green roofs, and bio retention swales or rain gardens. Multiple iterations were needed to identify which storm sewer modifications reduced flooding and which did not. The goal of these design criteria was to incorporate effective techniques, while disregarding designs which did not contribute to flood reduction.

Figure 4-5 shows the capacity of the storm sewer network for the base 10 year storm. The bottlenecks in the network include Salvesen Creek from E Avenue to B Avenue, the east-west main north of E Avenue near 6th Street, the main draining Pleasant View Circle, the main draining into the Central Drainage Ditch from A Avenue, and the main draining the area south of the softball practice fields. *In situ* modifications targeted the Pleasant View Circle and E Place neighborhoods because the techniques were effective at low flood events.

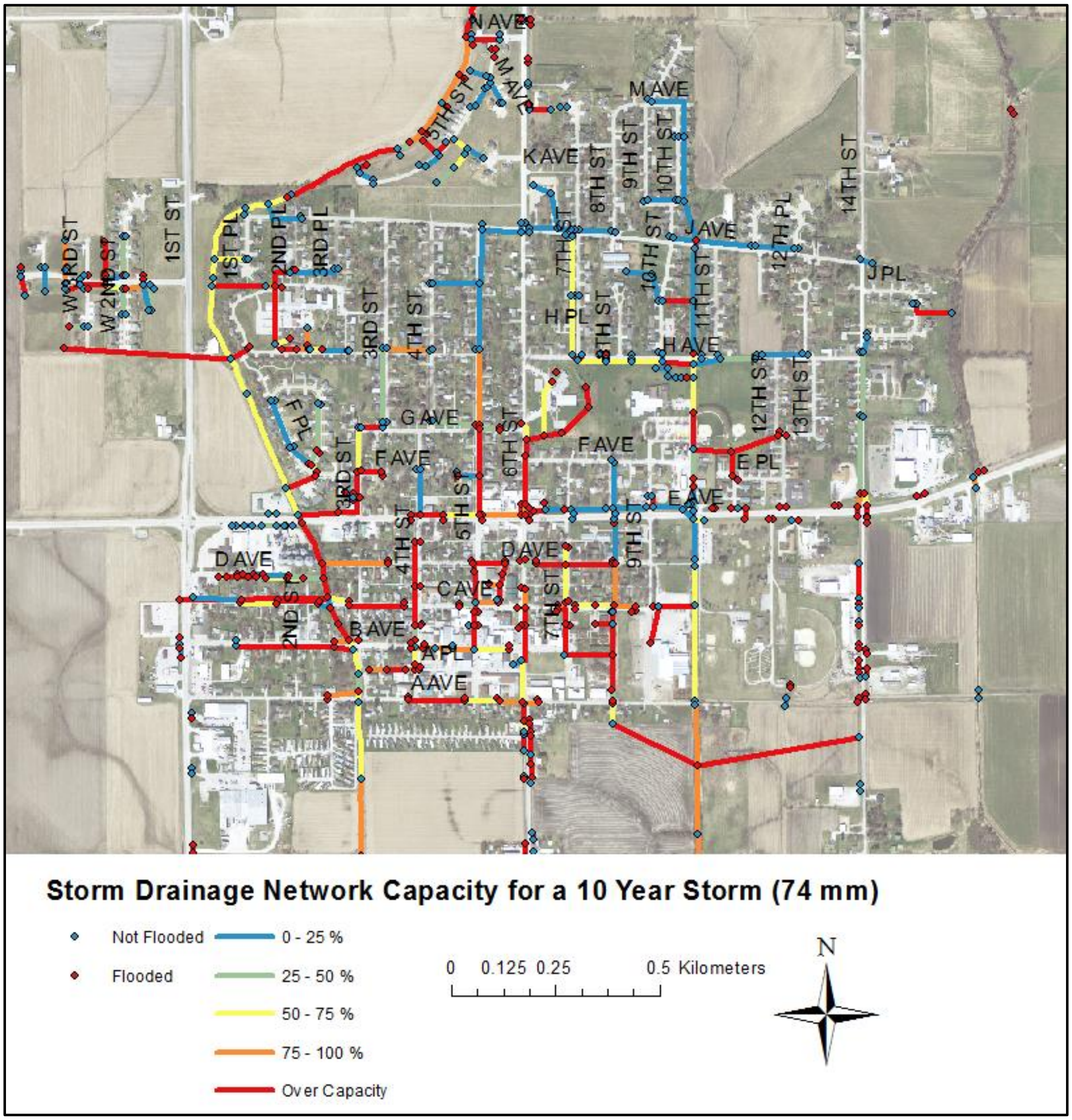


Figure 4-5: Node Flooding and Sewer Capacity for a 10 Year (74 mm) Storm

One dry detention basin north of the softball fields was included in the final design, as shown in Figure 4-6. This basin involved cutting into the ground until the invert elevation of the outlet pipe was reached. No embankment was included in this design. The primary outlet was a 12 inch RCP pipe leading to the Central Drainage Ditch from the lowest point in the southeast corner of the basin. The basin had 20% side slopes, and the base of the pond had a slope of 1.5% leading to the outlet. Even though this location for the primary outlet required a longer pipe, it allowed for a larger storage volume.

This basin was modeled via the 2D grid. A topographic plan was created and then directly uploaded into XPSWMM as an addition to the DEM. This was set at a higher priority than the current DEM. The primary outlet structure was a 1D conduit with the upstream node at the lowest point in the basin with the downstream node intersecting the storm sewer network. The secondary outlet was modeled via the 2D grid as well. It was located at the south east corner to allow flow to proceed south through its current trajectory.

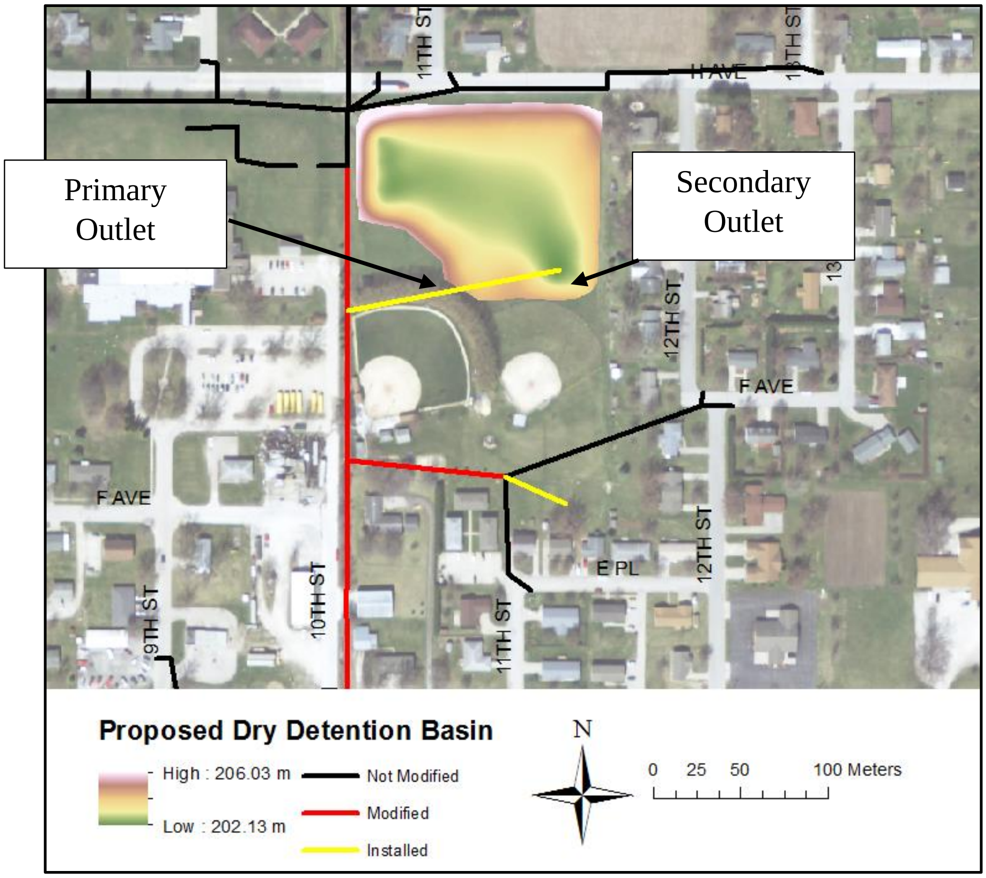


Figure 4-6: Proposed *In Situ* Detention Basin

An embankment was constructed at the west end of J Avenue to mitigate overflow from Salvesen Creek. As stated previously, overflow from Salvesen creek drained into the neighborhood, south down 1st Place and into Pleasant View Circle. This was because a depression formed in the topography west of J Avenue, funneling water down the street. The embankment filled this depression by interpolating the elevations between high points on either side. This was modeled using a “ridge” function in XPSWMM, which allowed the user to modify the elevations of specific cells at the vertices of a polyline.

Local runoff draining along H Avenue and Salvesen Creek overflow from the 1st Place neighborhood causes flooding in Pleasant View Circle. Four approaches mitigated this flooding, first, the embankment at J Avenue reduced overflow; second, the east-west drainage main under Pleasant View Circle west of H Avenue was expanded from an 8 inch (0.203 meters) PVC pipe to 12 inch (0.305 meters) RCP pipe. There is no curb along Pleasant View Circle, so the inlets were expanded from 8 inch (0.203 meters) circular grates to 12 inch (0.305 meters) circular grates. Third, the RCP pipe draining the 2nd and 3rd Place and Pleasant View Circle neighborhoods was expanded as well from 24 inches (0.61 meters) to 36 inches (0.914 meters). Fourth, the pipe draining Pleasant View Circle at the southwest corner was also expanded from an 18 inch (0.457 meters) ADS pipe to 24 inch (0.61 meters) ADS pipe.

An additional 18 inch (.457 meters) RCP pipe with a 4 foot (1.22 meters) curb opening was added at the northwest end of the cul-de-sac on 1st Place. The original pipe is at a high point along the road, so this new pipe allows for increased drainage.

The East Drainage Ditch culvert under E Avenue was also undersized, even if it did not flow completely full. Excess water overflows west parallel to E Avenue, inundating homes along 12th Street, 11th Street, and E Place. To mitigate this flooding, expansions were made in the culverts under E Avenue at the East Drainage Ditch. The East Drainage Ditch culvert is currently an 8 foot (2.44 meters) wide by 8.5 foot (2.59 meters) tall rectangular culvert, and was expanded to a double barrel 14 foot (4.27 meters) wide by 10 foot (3.05 meters) tall, each barrel being 58 feet (17.68 meters) long, similar to that under A, B, and C Avenues along Salvesen Creek. The new East Drainage Ditch culvert was modeled with the same inputs as A Avenue along Salvesen Creek.

At H Avenue, the Central Drainage Ditch changes from an open channel to a 5.2 foot (1.58 meters) underground pipe, daylighting again about halfway between H Avenue and E Avenue. The ditch goes through a 4.4 foot (1.34 meters) culvert under a driveway before entering an 8 foot (2.44 meters) wide by 4 foot (1.22 meters) tall rectangular culvert at E Avenue. The culvert has two sections with a mild slope and one in the middle with a steep slope, averaging an 8.6% grade throughout the structure. The upstream end of the E Avenue culvert was lowered 4.26 feet (1.3 meters) so it would have a slope of 2%. The upstream open channels and the driveway culvert were lowered as well, with the top of bank elevation staying the same, to increase flow area.

The purpose of these ditch modifications was to increase the slope of the 20 inch (0.51 meters) pipe draining the area south of the softball fields, remove sediment buildup in the pipe, increase the cross sectional area of the channel, and allow for a deeper dry detention basin. The subterranean portions of the Central Drainage Ditch were lowered to match the invert elevations of the open channel section up to the current intersection of the Mid-Prairie Middle School detention basin outlet and the pipe. The intake grate currently in the area south of the softball fields is above the most depressed area. Therefore, a new 12 inch (0.305 meters) pipe with a 2 foot (0.61 meters) intake grate was added to increase the capacity of the sewer. Figure 4-7 shows the location of each modification.

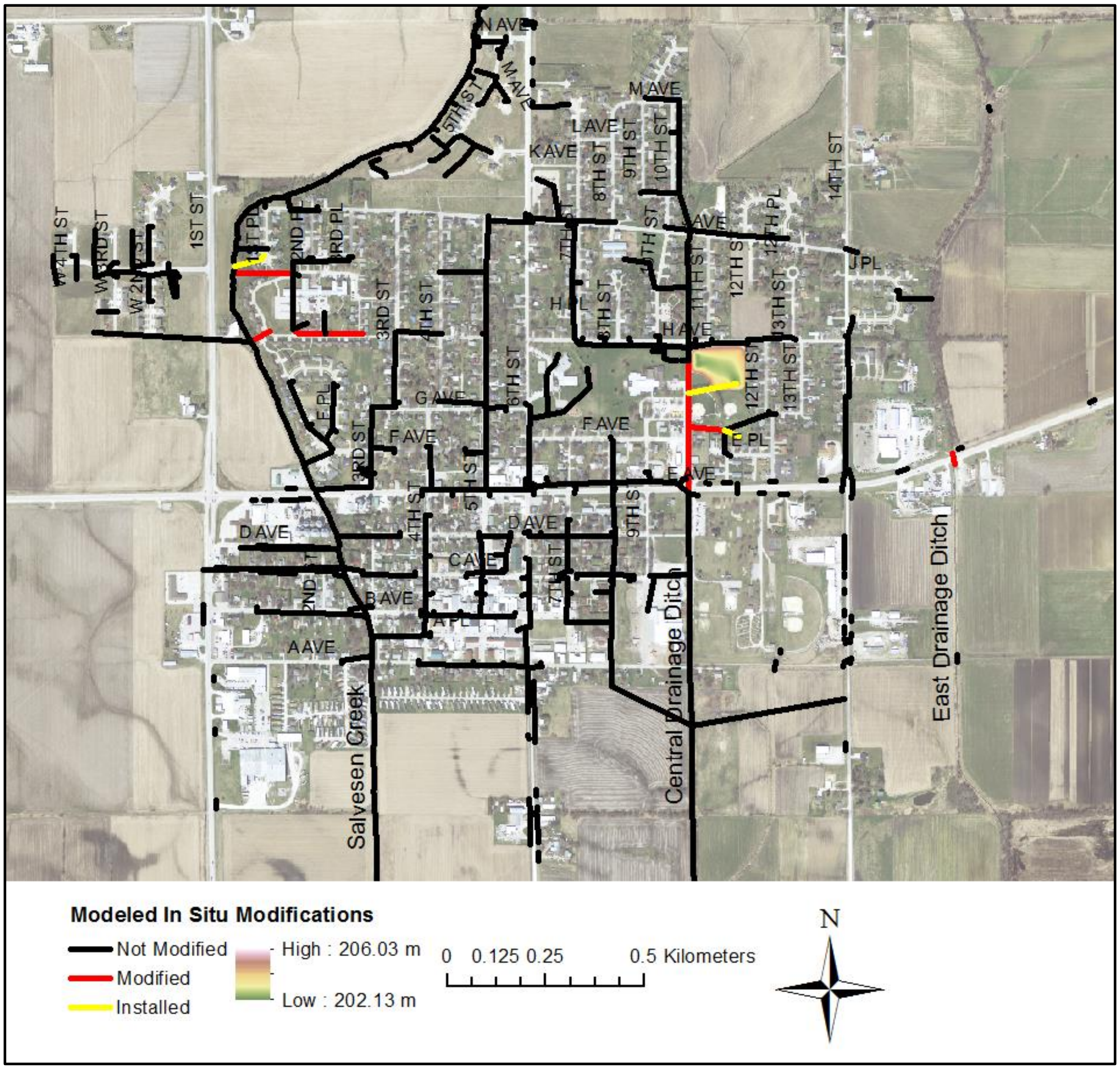


Figure 4-7: Modeled *In Situ* Modifications

Figure 4-8, Figure 4-9, and Figure 4-10 show the total inundation for the 10 year, 100 year, and 500 year storms with the modeled *in situ* flood mitigation techniques, respectively. The expanded E Avenue culvert over the East Drainage Ditch allowed more flow to pass through instead of being diverted to property along E Avenue. This caused flood reductions on the north side of E Avenue while adding to flooding at agricultural fields south of E Avenue. The dry detention basin north of the softball fields decreased much of the flooding on the north side of E Place. However, flow still enters the area via the northeast, from the intersection of 12th Street and F Avenue. At high floods, the effectiveness of the detention pond and other modifications decreased as they became overwhelmed.

Total inundation was almost unchanged at City Hall. This was because modifications to the storm sewer network to alleviate this flooding failed. Multiple problems arose while trying to modify the storm sewer network: a shallow elevation gradient and backwater effects from Salvesen Creek and the drainage ditches. In pipe networks with a high slope, inverts could be lowered in order to expand the pipe while still maintaining the 2 feet (0.61 meters) minimum cover necessary and a slope large enough to ensure proper conveyance. However, this was not possible in many areas because the pipe crowns were already at or exceeded the minimum cover, and slope was near zero. Backwater effects also contributed to the flooding problems. Even for the low intensity storms, the Central Drainage Ditch had substantial backwater effects on the drainage system along E Avenue. Increasing the capacity of the storm sewers only minimally increased the peak flow in pipes under E Avenue, where local runoff and Salvesen Creek overflow converge. Therefore, storm sewer modifications alone were unable to effect the flooding east of downtown. Figure 4-11, Figure 4-12, and Figure 4-13 show the total flood reduction for the modeled *in situ* modification strategies for the 10 year, 100 year, and 500 year storms, respectively. The 25 year and 50 year inundation and reduction maps can be found in APPENDIX C.

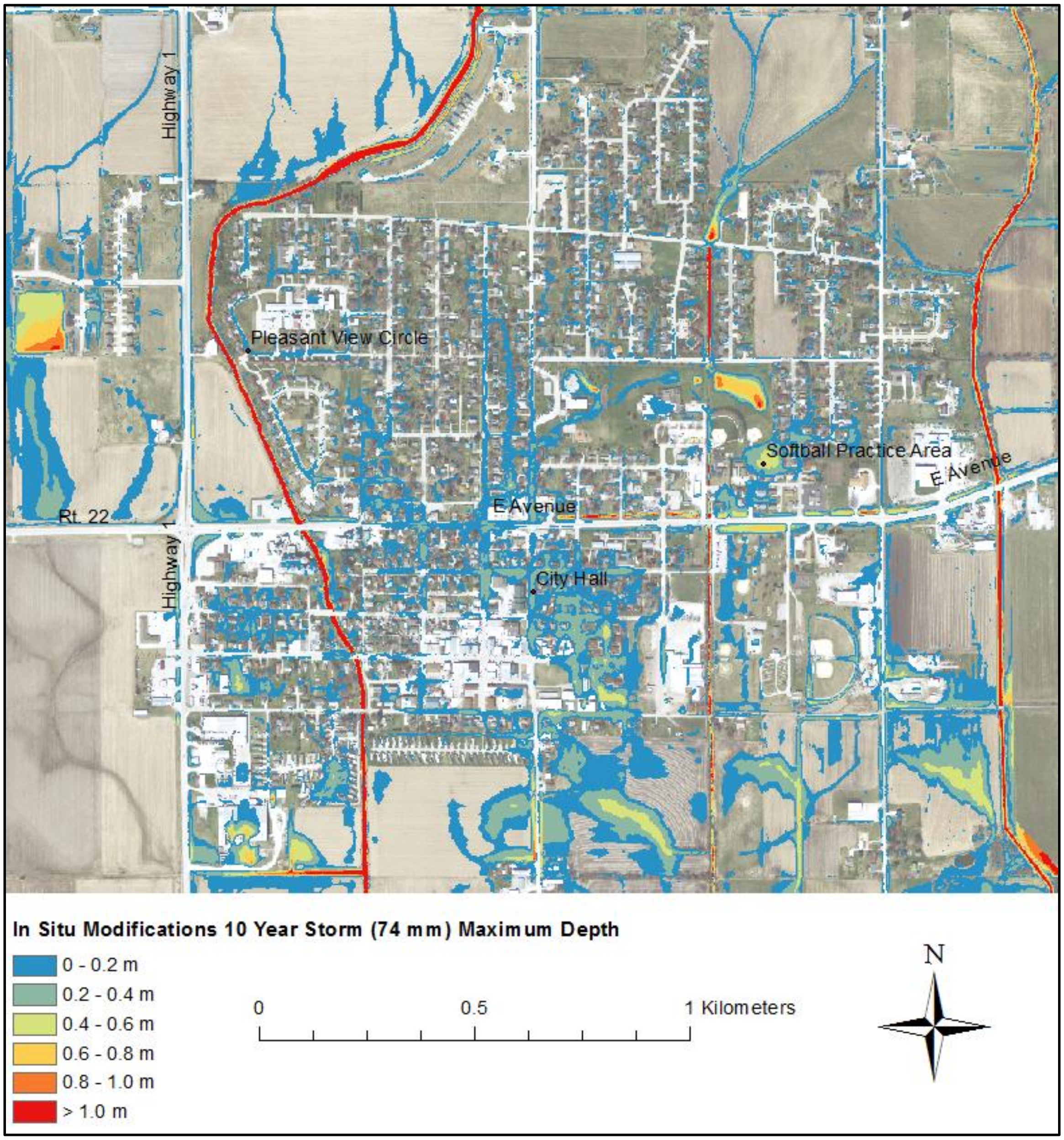


Figure 4-8: Maximum Depth for a 10 Year (74 mm) Storm with *In Situ* Modifications

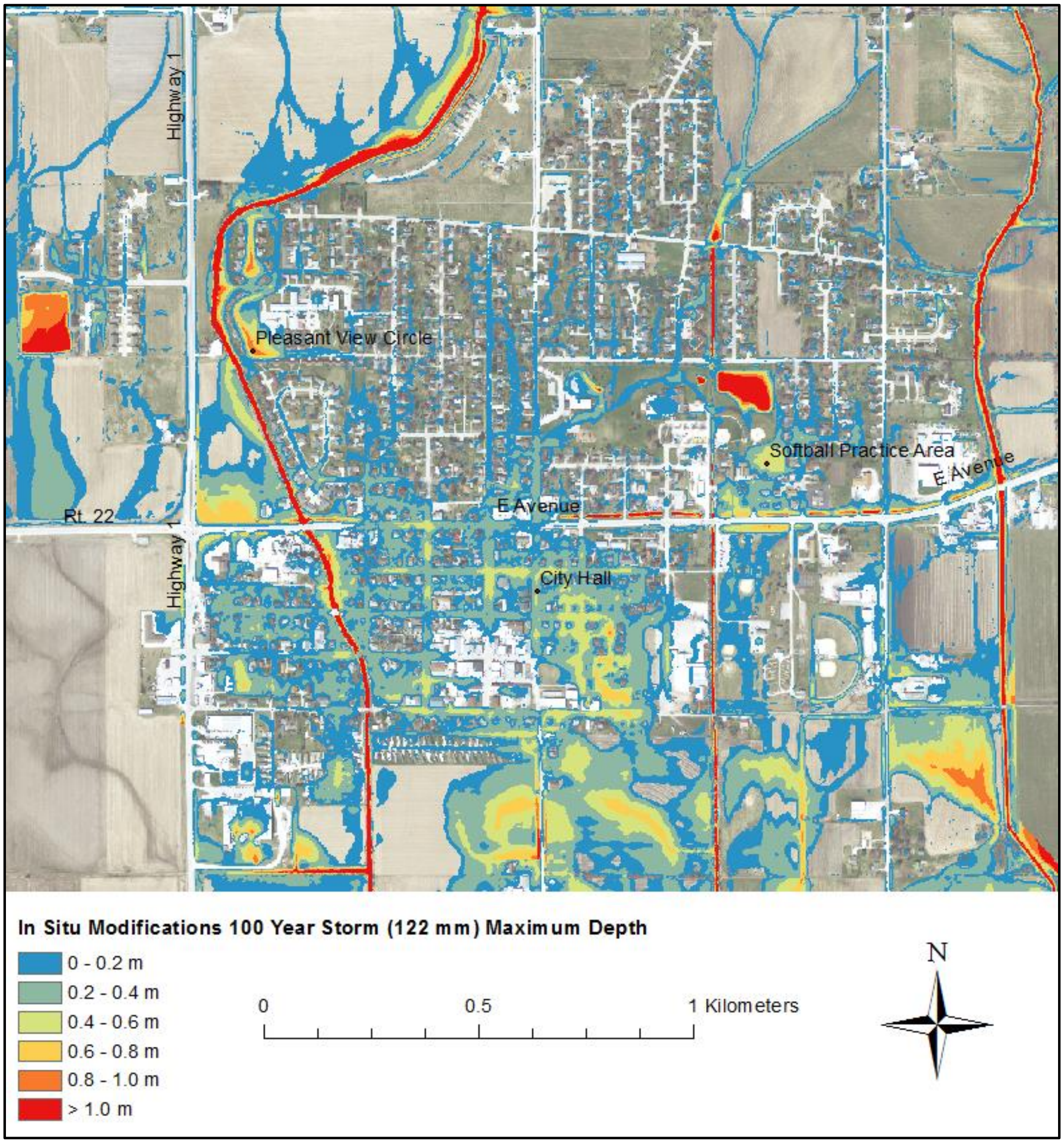


Figure 4-9: Maximum Depth for a 100 Year (122 mm) Storm with *In Situ* Modifications

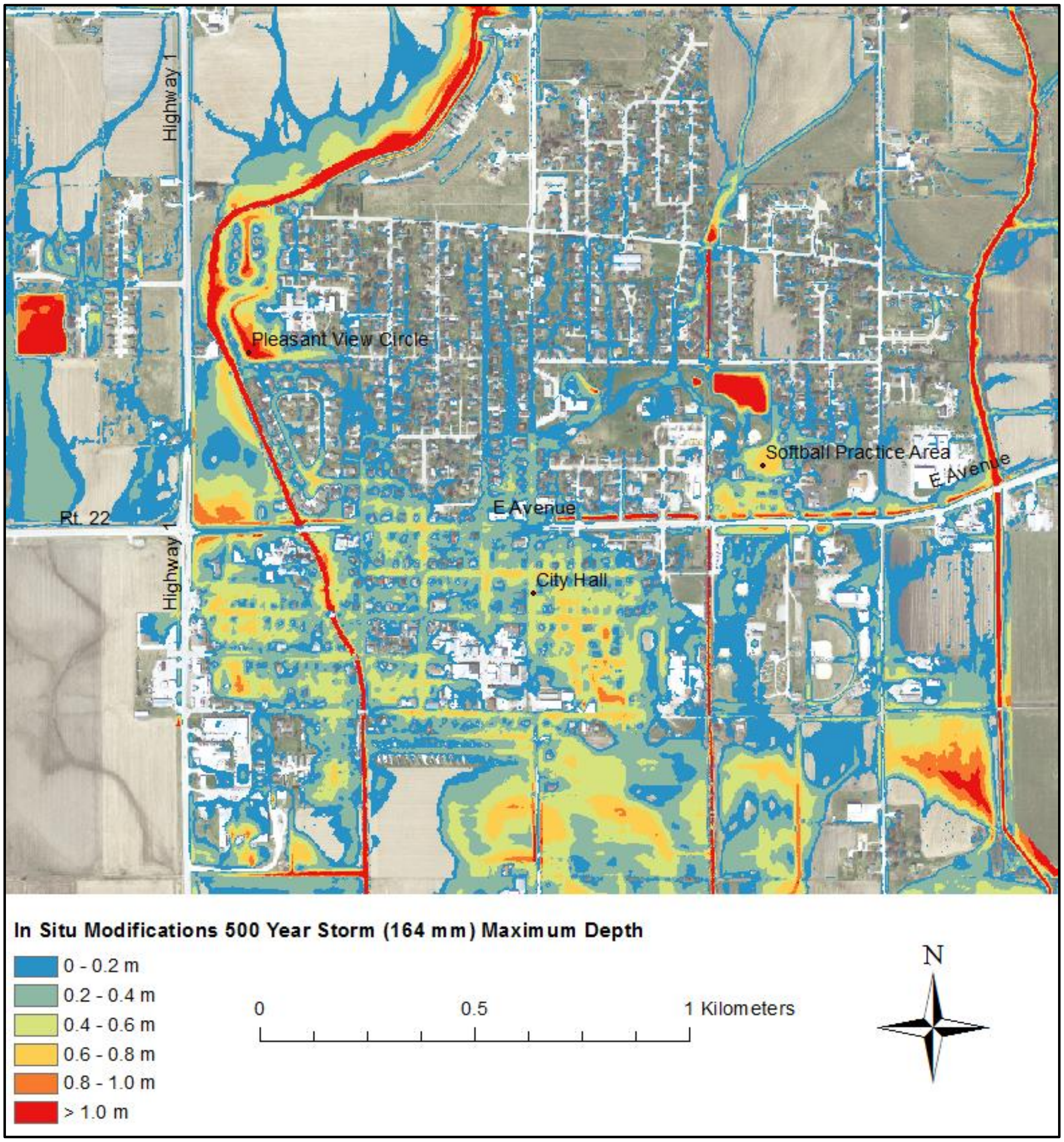


Figure 4-10: Maximum Depth for a 500 Year (164 mm) Storm with *In Situ* Modifications

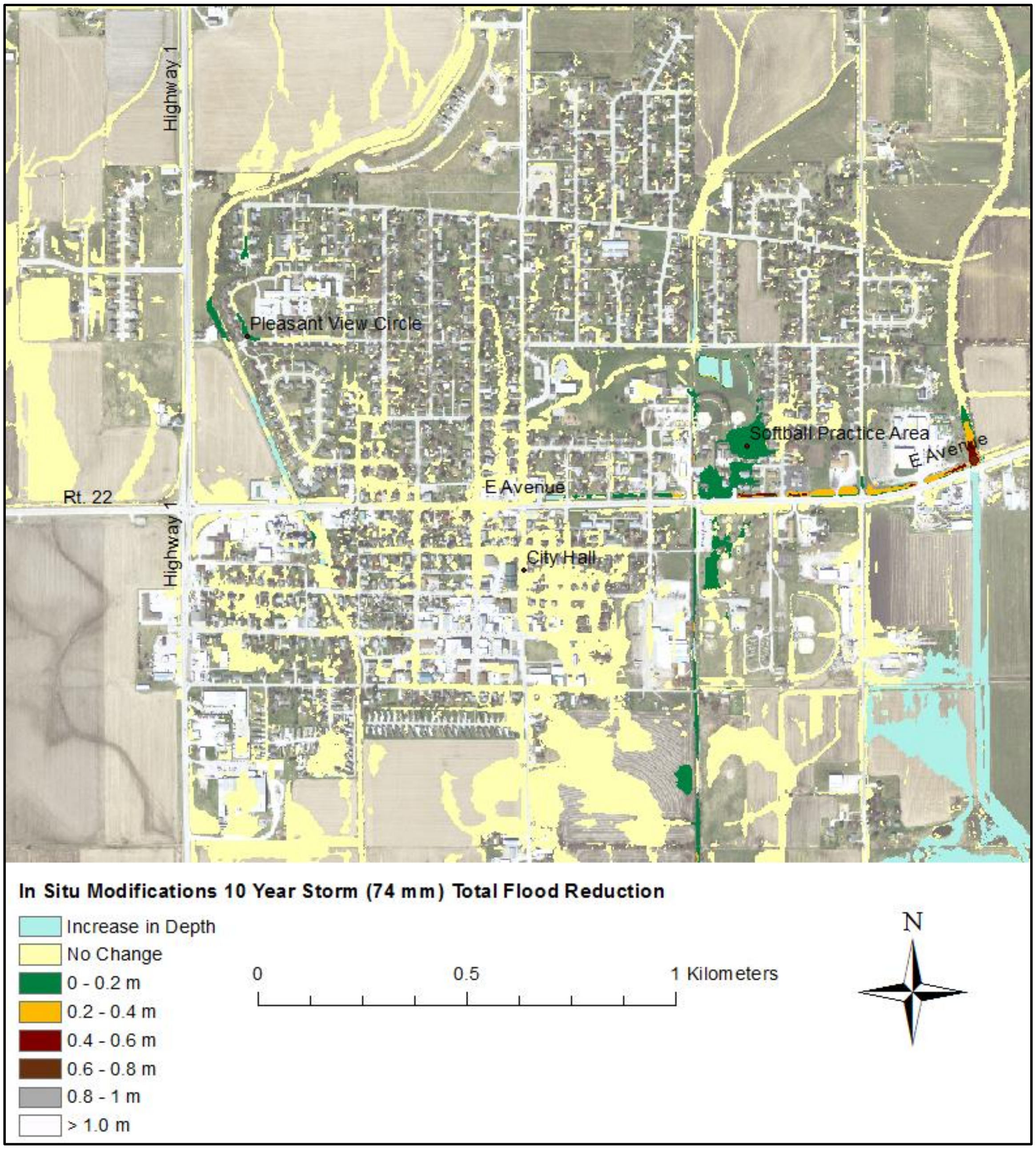


Figure 4-11: Total Flood Reduction for a 10 Year (74 mm) Storm with *In Situ* Modification Flood Mitigation Techniques

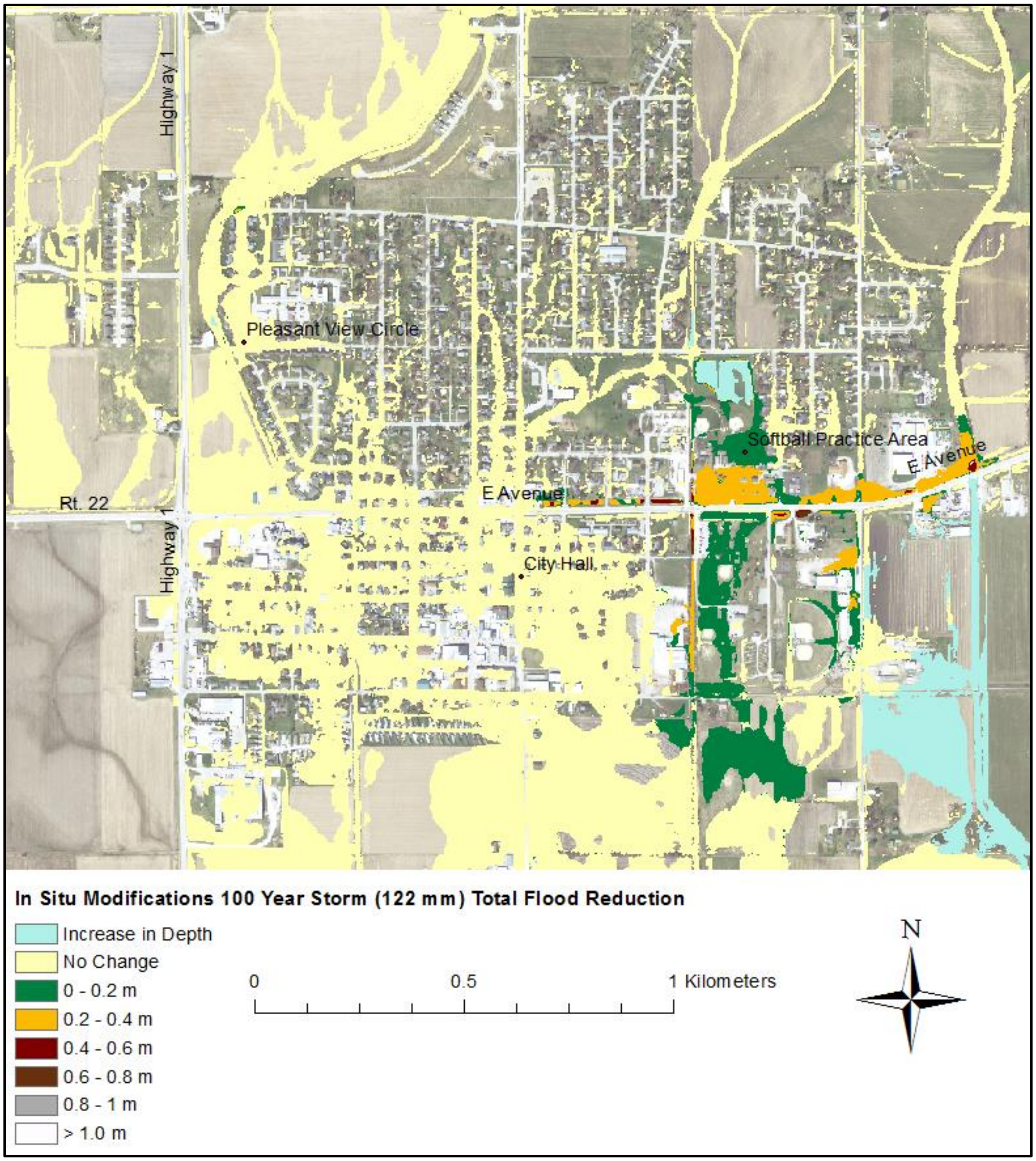


Figure 4-12: Total Flood Reduction for a 100 Year (122 mm) Storm with *In Situ* Modification Flood Mitigation Techniques

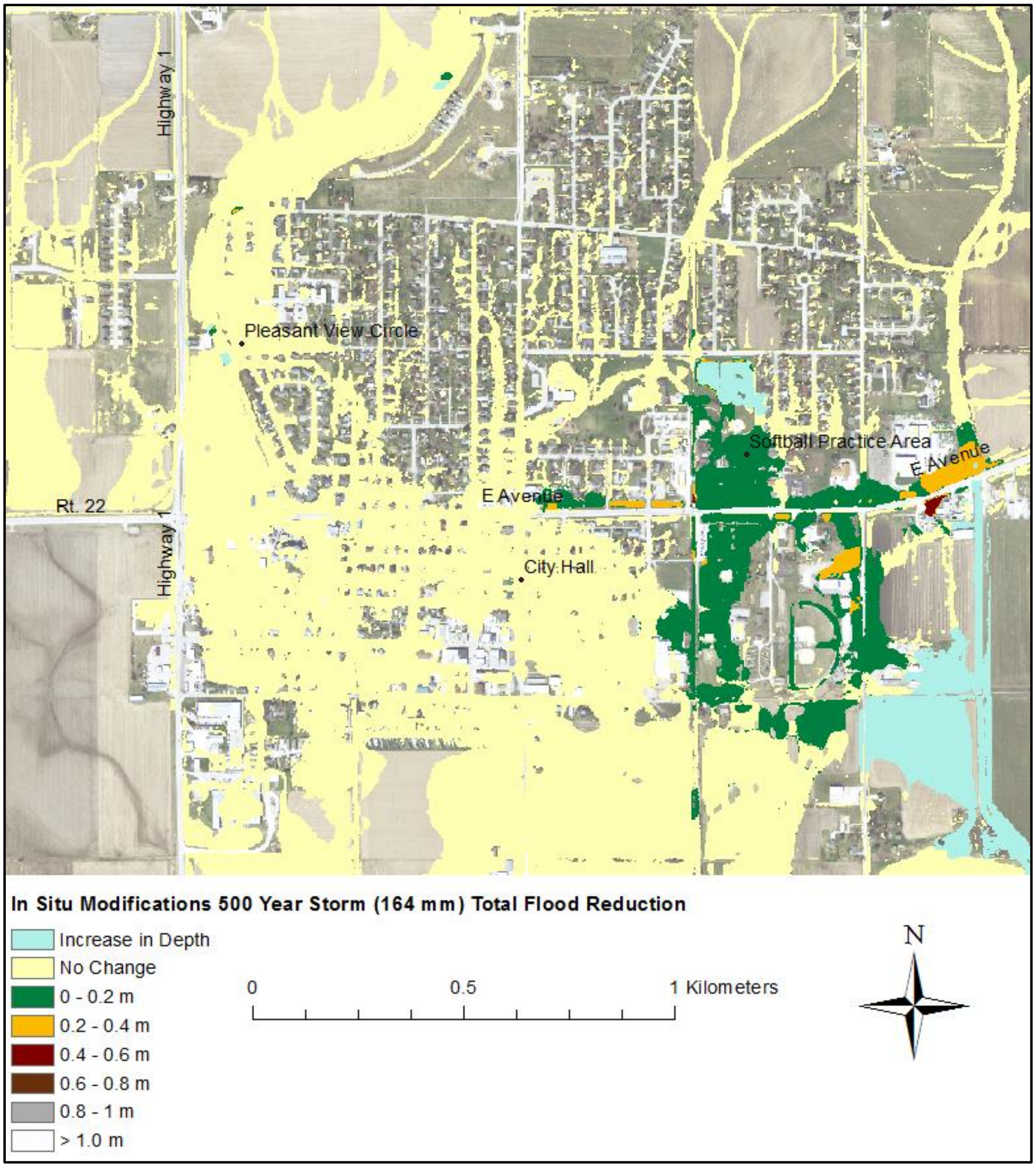


Figure 4-13: Total Flood Reduction for a 500 Year (164 mm) Storm with *In Situ* Modification Flood Mitigation Techniques

Table 4-3 and Table 4-4 show the maximum depth at each index point for each storm and the total reduction when compared to the base storms, respectively. As expected, there was little reduction at City Hall. The maximum depth even increased during the 10 year storm. Significant reductions occurred in the Pleasant View Circle neighborhood and the Softball Practice Area. However, the Pleasant View Circle neighborhood reductions peaked during the 50 year storm then decreased as the embankment at J Avenue was overtopped and the sewer network was overwhelmed. During both the 100 and 500 year storms, flood reduction at Pleasant View Circle was negligible. The flood reduction strategies along the Central Drainage Ditch succeeded in significantly reducing the peak depth at the Softball Practice Area up to the 100 year storm. The 500 year storm overwhelmed these improvements as well and decreased the effectiveness of the techniques.

Table 4-3: Maximum Depths at Each Index Point using *In Situ* Modifications Flood Reduction Technique

In Situ Modifications Maximum Depth (m)					
Index Point	10 Year Storm Depth (74 mm)	25 Year Storm Depth (92 mm)	50 Year Storm Depth (106 mm)	100 Year Storm Depth (122 mm)	500 Year Storm Depth (164 mm)
Pleasant View Circle	0.19	0.30	0.65	1.00	1.36
Softball Practice Area	0.51	0.55	0.58	0.61	0.78
City Hall	0.24	0.27	0.33	0.39	0.53

Table 4-4: Total Flood Reduction at Each Index Point using *In Situ* Modifications Flood Reduction Technique

In Situ Modifications Reduction					
Index Point	10 Year Storm Reduction (74 mm)	25 Year Storm Reduction (92 mm)	50 Year Storm Reduction (106 mm)	100 Year Storm Reduction (122 mm)	500 Year Storm Reduction (164 mm)
Pleasant View Circle	44%	53%	26%	3%	1%
Softball Practice Area	18%	21%	22%	22%	11%
City Hall	0%	0%	1%	2%	2%

Table 4-5 shows the performance of the storm sewers using the *in situ* modification technique. The pipes and manholes lists used to create these numbers were the same for the base model in order to make a direct comparison. The modifications did not significantly improve the performance of the entire storm sewer network. This was expected because the modifications targeted specific areas, rather than to increase the capacity of the network as a whole. Even though the modified pipes were still at over capacity during the low flood events as well, they were able to drain a higher volume of water.

Table 4-5: *In Situ* Modifications Storm Sewer Performance

In Situ Modifications Storm Sewer Network Performance		
Storm	Manholes Flooded	Storm Sewers at Over - Capacity
10 Year (74 mm)	51%	29%
25 Year (92 mm)	58%	33%
50 Year (106 mm)	60%	35%
100 Year (122 mm)	64%	38%
500 Year (164 mm)	70%	43%

4.4 Upstream Agricultural Detention Ponds

14 pond locations were chosen based on basin size, outlet structures, and downstream conditions. Figure 4-14 shows the location and extent of the proposed ponds. The purpose of these ponds was to store runoff up to the 100 year event and discharge it at a lower rate for a longer duration. For modeling purposes, each pond was located without consultation with landowners. No pond has permanent structures within the storage area. Further details on each pond can be found in APPENDIX L.

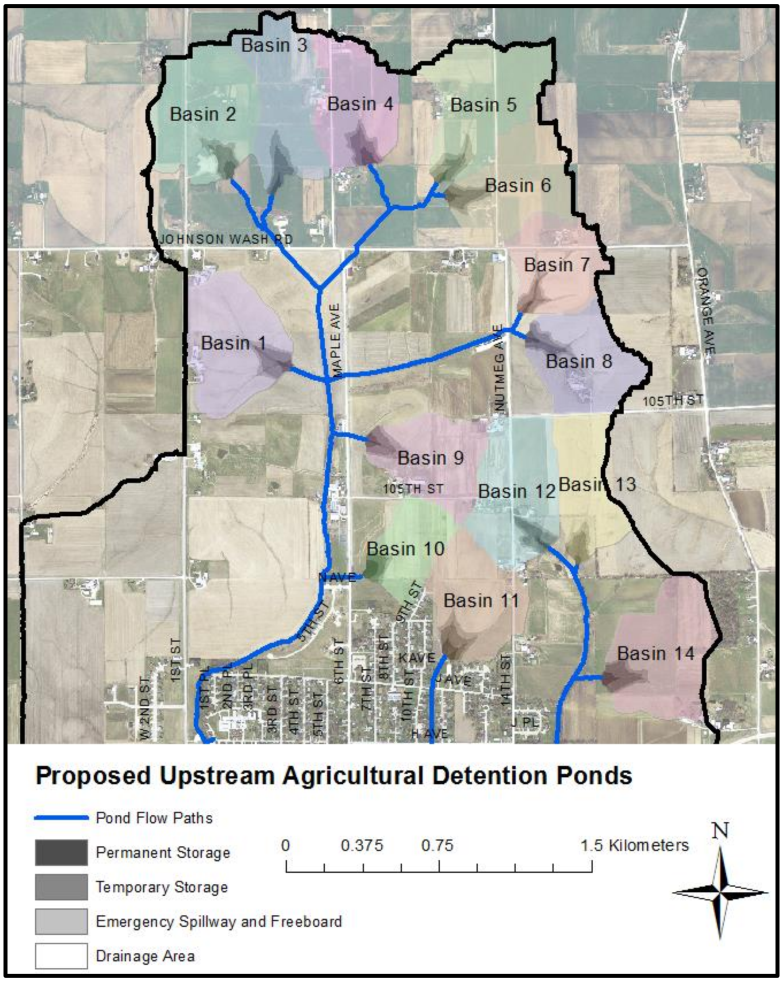
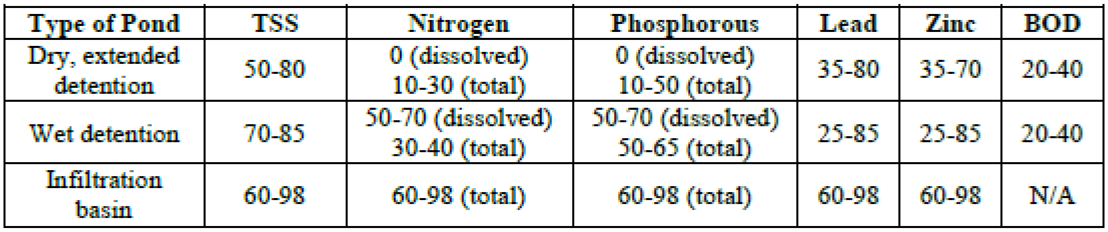


Figure 4-14: Proposed Pond Locations

10 catchments were selected upstream of Salvesen Creek, while one and three catchments were selected upstream of the Central Drainage Ditch and East Drainage Ditch, respectively. Each catchment was between 30 and 75 acres. Kalona officials described a specific desire for a pond north of the Central Drainage Ditch. Agricultural drainage ponds were selected over dry detention basins due to their multiplicity of uses and benefits. Ponds can increase the land value of local real estate, which would be beneficial to homes along 12th Place and 10th Street upstream of the Central Drainage Ditch. They can also decrease pollutant concentrations and provide water for irrigation and livestock, as well as fire protection. If desirable, ponds can also be used for recreational purposes. However, water quality monitoring would be necessary to ensure safety. Dry detention basins, ponds, and infiltration basins each have water quality benefits as well. Table 4-6 compares the pollutant removal potential between dry, wet, and infiltration basins (US Environmental Protection Agency 1999).

Table 4-6: Concentrations of Pollutants Removed from Different Detention Facilities (US Environmental Protection Agency 1999)



Type of Pond	TSS	Nitrogen	Phosphorous	Lead	Zinc	BOD
Dry, extended detention	50-80	0 (dissolved) 10-30 (total)	0 (dissolved) 10-50 (total)	35-80	35-70	20-40
Wet detention	70-85	50-70 (dissolved) 30-40 (total)	50-70 (dissolved) 50-65 (total)	25-85	25-85	20-40
Infiltration basin	60-98	60-98 (total)	60-98 (total)	60-98	60-98	N/A

A standard pond design process was established using guidelines published by the NRCS and Iowa DNR (Natural Resources Conservation Service 1997, Iowa Department of Natural Resources 2010). Emergency spillways and embankments were designed using specifications listed by the Iowa DNR (Iowa Department of Natural Resources 1990). Supplementary material was provided by other sources (Chin 2013, Virginia Department of Conservation and Recreation 1999). Each pond was modeled using only an embankment. No storage was “cut” into the existing topography.

Minimum design criteria included an ability to store runoff from the 100 year event without activating the secondary outlets, 2 feet (0.61 meters) of freeboard added to the 500 year overflow over the emergency spillway, and 5 feet (1.52 meters) of permanent storage. The embankments were modeled by inactivating the cells surrounding the catchment from the low point to the desired elevation. It was assumed that no water would overtop the embankment. The inactive area measured 19.7 feet (6 meters) across, which is wider than the recommended width of 10 - 12 feet (3.05 – 3.66 meters), but was necessary to ensure the inactivation of cells. Figure 4-15 shows the typical design for each pond.

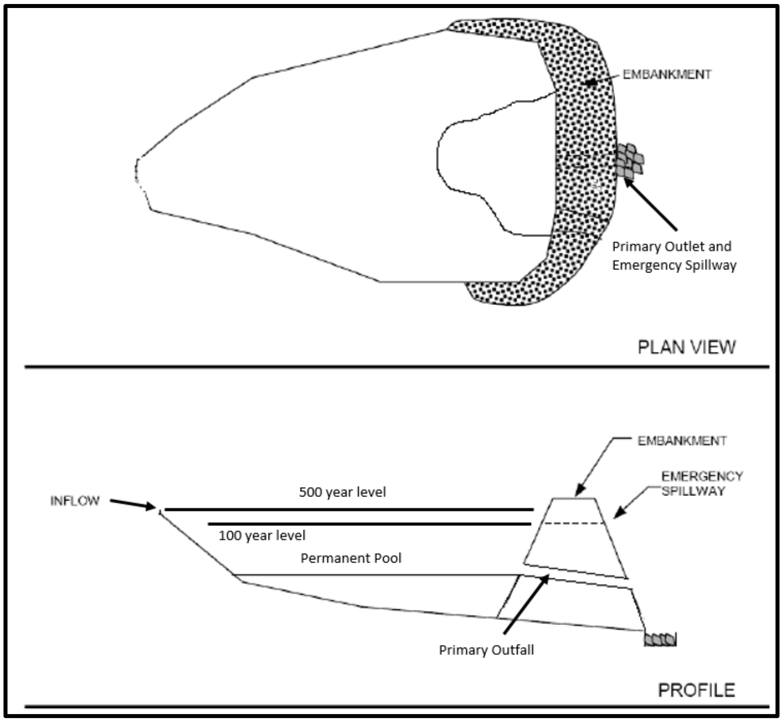


Figure 4-15: Detention Pond Design
(Iowa Department of Natural Resources 2010)

It was assumed neither infiltration nor evaporation caused losses to the permanent storage because of a water proof liner and short simulation time, respectively. Therefore, permanent storage could be modeled using the DEM instead of setting an initial depth in the model. 1.6 meters was added to the lowest flow point of each catchment. This elevation was then leveled until it reached the catchment sides. DEM files for each pond were added to the model and given priority over the base DEM. The primary outlet invert was set at the permanent pool elevation, simulating the boundary between temporary and permanent storage. Each outlet was a 12 inch (0.305 meters) RCP pipe, with inverts set to the level of the DEM upstream and downstream of the embankment.

Earthen trapezoidal spillways were chosen as the secondary outlet. Each spillway was set to the peak 100 year water surface elevation. This was determined by running the model with a 100 year storm with unrealistically long embankments to capture all runoff in the catchment. The same method was employed to determine the peak 500 year water surface elevation, although with unrealistically tall emergency spillways. 2 feet of freeboard were added to the resultant maximum water surface elevation to complete the embankment design. Each spillway had a base width of 10 feet (3.05 meters), side slopes of 3:1 H:V, base slope of 10%, and Manning's Coefficient of 0.03, according to Iowa DNR Specifications (Iowa Department of Natural Resources 1990)

Both the primary and secondary outlets were modeled together as multilinks. The primary outlet was a circular pipe, while the secondary outlet was an internal rating curve. Each pond had a unique rating curve calculated using the minimum water surface elevation necessary to activate the spillway and the total embankment height. The Manning's equation calculated flow using the spillway geometry at 0.05 meter head intervals.

Figure 4-16, Figure 4-17, and Figure 4-18 show the total inundation maps using agricultural detention ponds for the 10 year storm, 100 year storm, and 500 year storm, respectively. Figure 4-19, Figure 4-20, and Figure 4-21 show the total flood reductions for the 10 year storm, 100 year storm, and 500 year storm, respectively. The inundation and flood reduction maps for the 25 year and 50 year storms can be found in APPENDIX D.

The ponds succeeded in reducing flooding in areas impacted by creek overflow. Specifically, the 1st Place, Pleasant View Circle, and E Place neighborhoods experienced a reduction in peak flood depth. Neighborhoods along A, B, C, and D Avenues alongside Salvesen Creek also experienced peak depth reductions during high flood conditions.

Overflow along E Avenue to the east decreased as well, easing flooding to the east of downtown. However, areas where flooding was due to local runoff saw no reduction. No basin secondary spillways experienced significant flow during the 100 year storm, while every spillway was activated during the 500 year storm. This caused several areas to experience less reduction during the 500 year storm when compared to the 100 year storm. However, this was minimal because the peak flow over the spillways occurred after the peak flow in the creeks. No spillway had flow within 2 feet of the embankment top. The 1st Place and E Place neighborhood had decreased flood reduction benefits from the 100 year storm to the 500 year storm due to flow over the spillways.

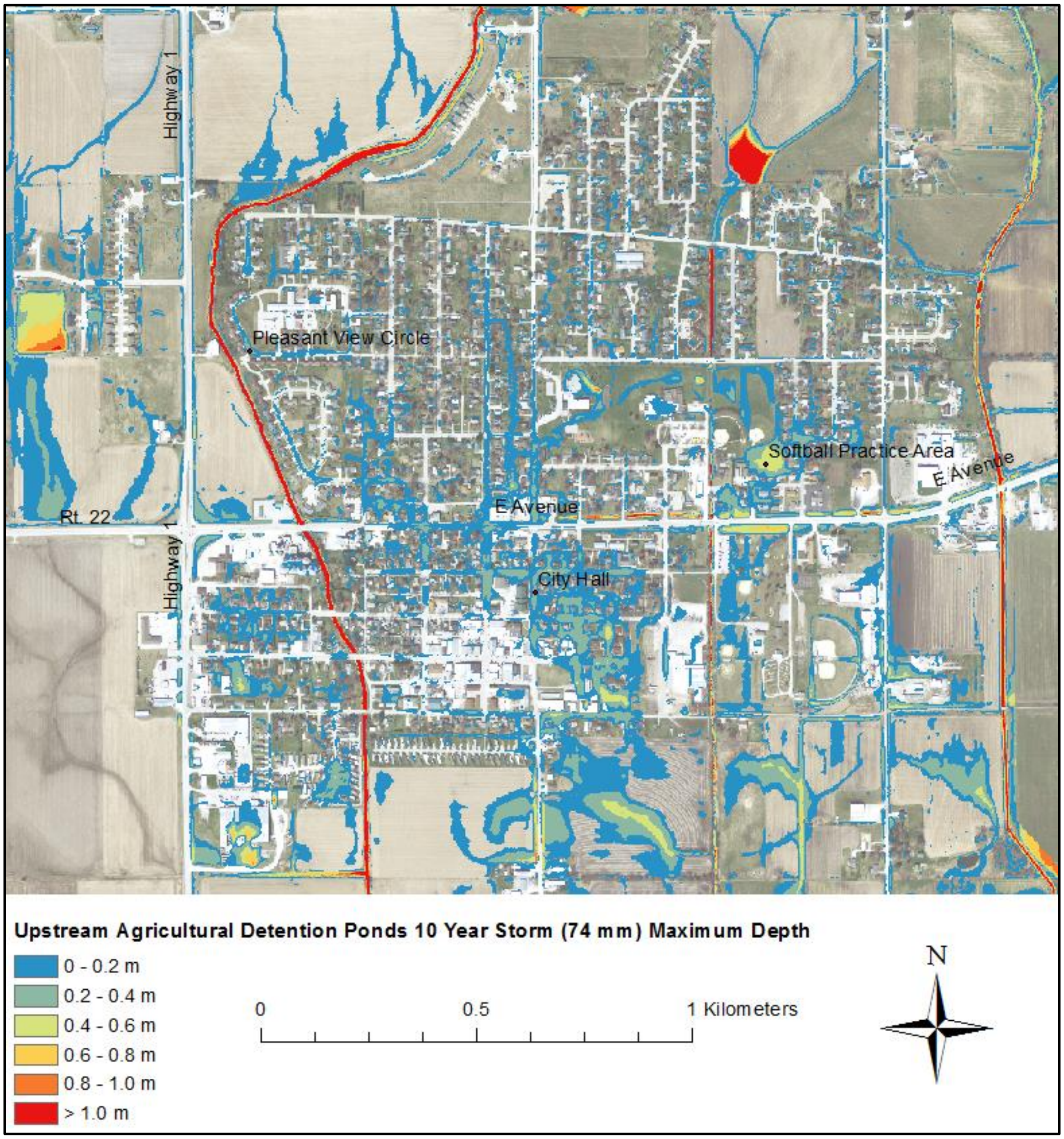


Figure 4-16: Maximum Depth for a 10 Year (74 mm) Storm with Upstream Agricultural Detention Ponds

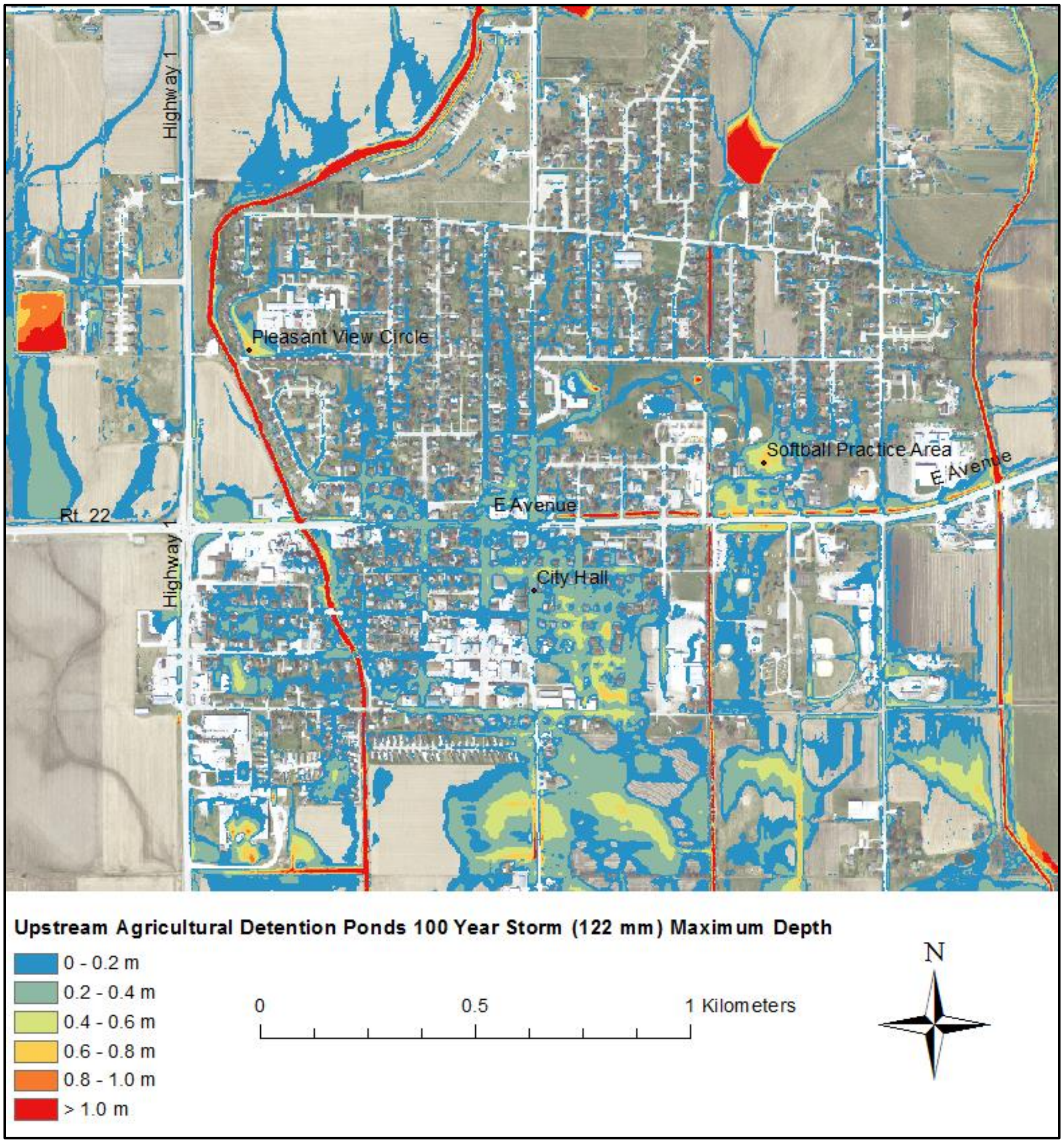


Figure 4-17: Maximum Depth for a 100 Year (122 mm) Storm with Upstream Agricultural Detention Ponds

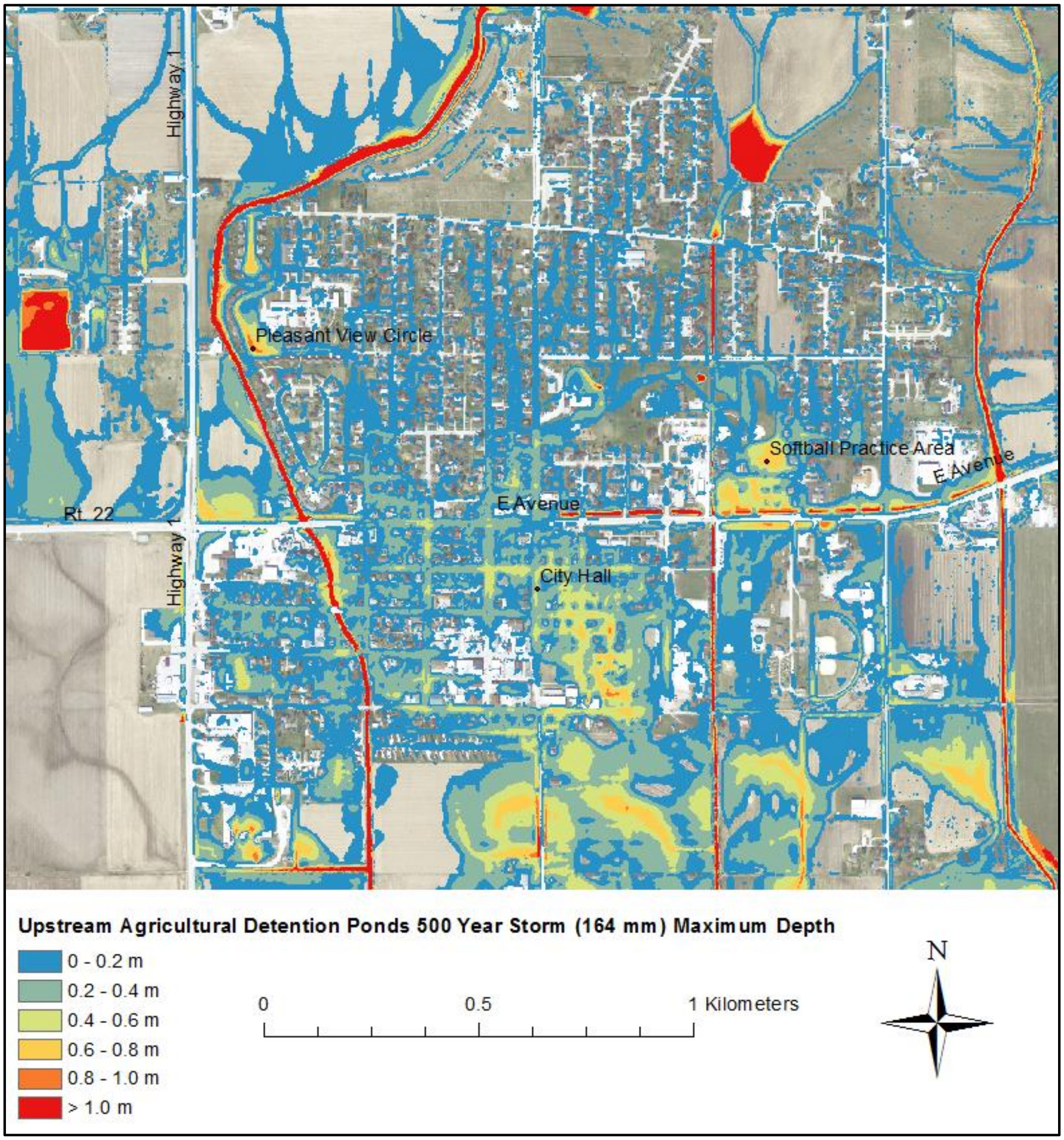


Figure 4-18: Maximum Depth for a 500 Year (164 mm) Storm with Upstream Agricultural Detention Ponds

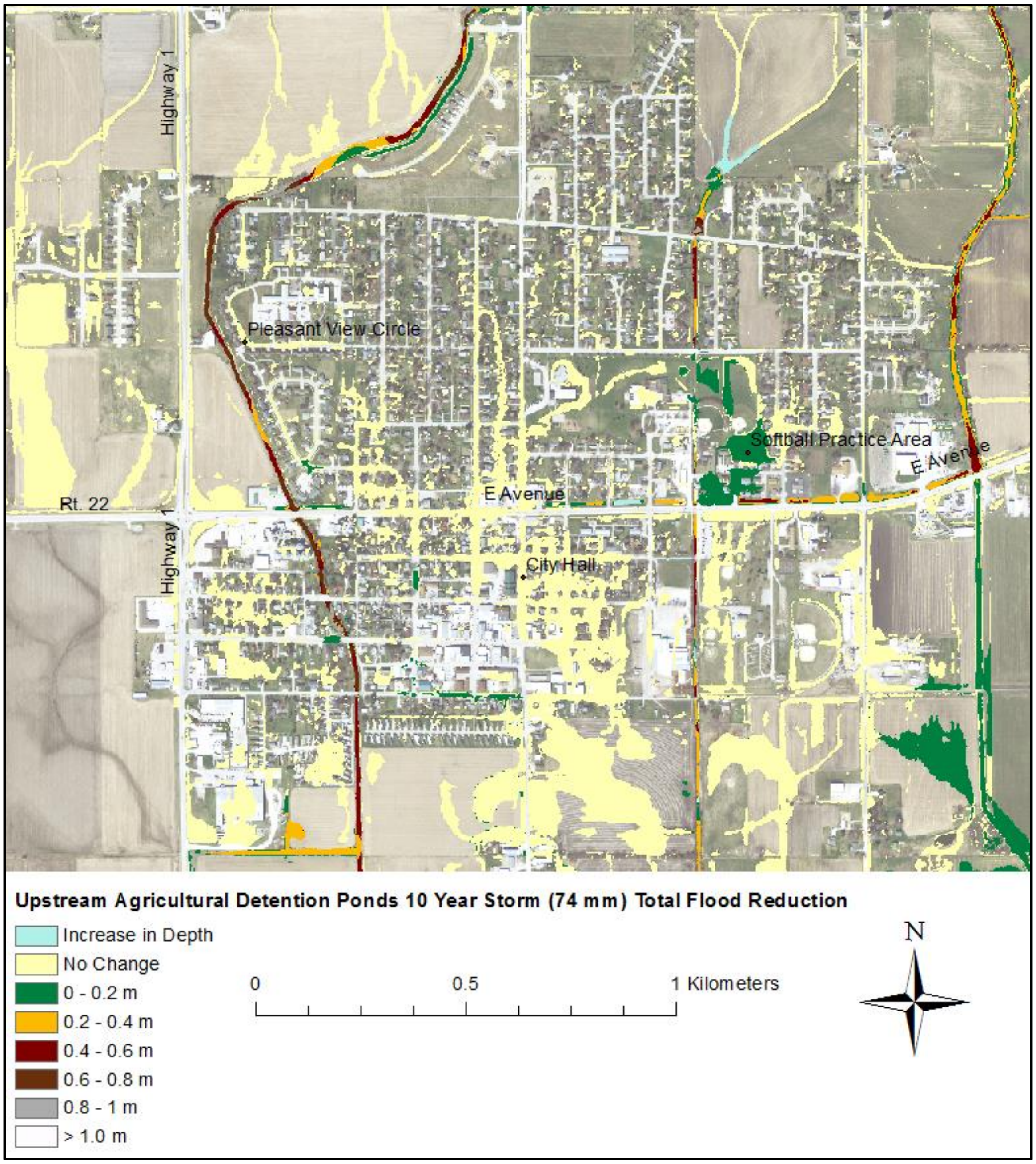


Figure 4-19: Total Flood Reduction for a 10 Year (74 mm) Storm with Upstream Agricultural Detention Ponds

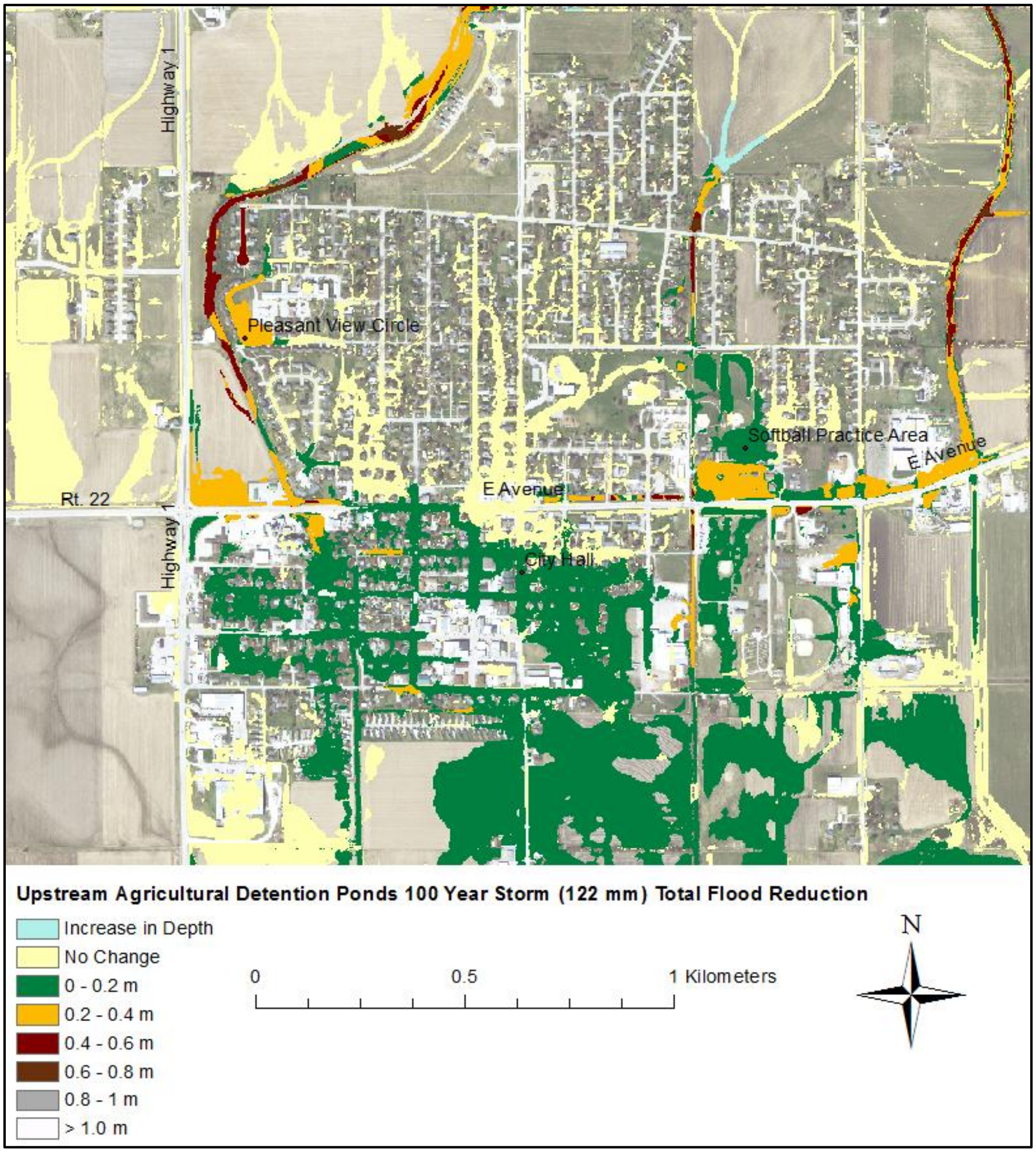


Figure 4-20: Total Flood Reduction for a 100 Year (122 mm) Storm with Upstream Agricultural Detention Ponds

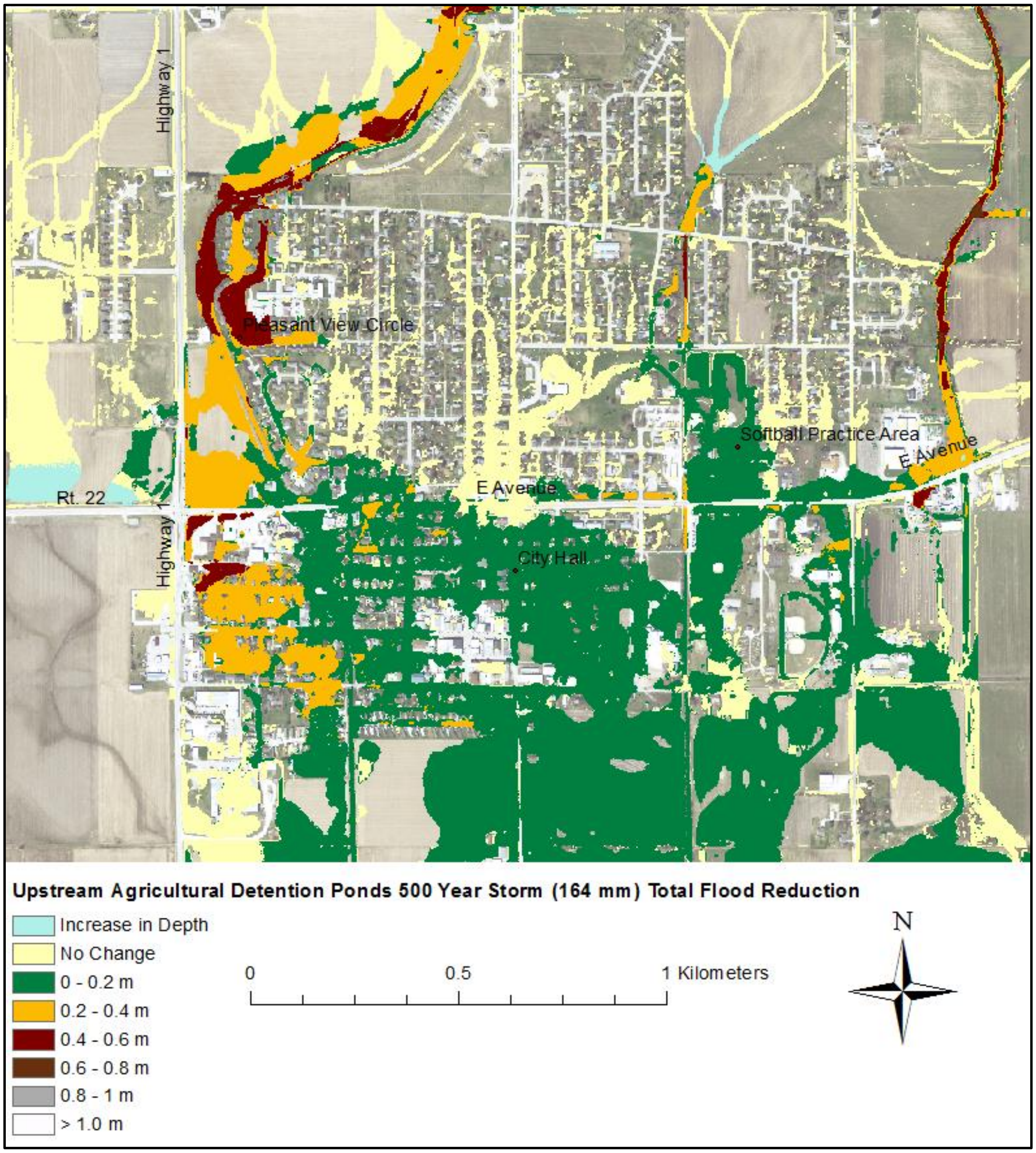


Figure 4-21: Total Flood Reduction for a 500 Year (164 mm) Storm with Upstream Agricultural Detention Ponds

Table 4-7 and Table 4-8 show the maximum depths and percent reduction compared to the base model, respectively. The detention pond method eased flooding at each index point, with the greatest being the Pleasant View Circle neighborhood. However, substantial reductions were not noticed until the 50 year storm at City Hall. This is because much of the flooding at City Hall can be contributed to local runoff upstream within Kalona. In areas where the primary cause of flooding is creek overflow, this method was effective at reducing peak depths.

Table 4-7: Maximum Depths at Each Index Point Using the Agricultural Detention Ponds Flood Reduction Technique

Upstream Agricultural Detention Ponds Maximum Depth (m)					
Index Point	10 Year Storm Depth (74 mm)	25 Year Storm Depth (92 mm)	50 Year Storm Depth (106 mm)	100 Year Storm Depth (122 mm)	500 Year Storm Depth (164 mm)
Pleasant View Circle	0.30	0.52	0.70	0.79	0.93
Softball Practice Area	0.56	0.61	0.64	0.68	0.76
City Hall	0.23	0.27	0.30	0.33	0.41

Table 4-8: Total Flood Reduction at Each Index Point Using the Agricultural Detention Pond Flood Reduction Technique

Upstream Agricultural Detention Ponds Reduction					
Index Point	10 Year Storm Reduction (74 mm)	25 Year Storm Reduction (92 mm)	50 Year Storm Reduction (106 mm)	100 Year Storm Reduction (122 mm)	500 Year Storm Reduction (164 mm)
Pleasant View Circle	13%	19%	20%	24%	32%
Softball Practice Area	9%	13%	14%	14%	13%
City Hall	2%	2%	10%	17%	24%

The upstream detention ponds had a larger effect than the *In situ* modifications on the performance of the storm sewer network. Table 4-9 shows the performance using the upstream agricultural detention ponds. However, during and after the 25 year storm, the majority of manholes were flooded and a large percentage of the sewer pipes were over capacity. During the 10 year storm, manholes along the east and west banks of Salvesen Creek experienced less surcharging due to decreased backflow. These manholes were flooded during and after the 25 year event.

Table 4-9: Upstream Agricultural Detention Ponds Storm Sewer Network Performance

Upstream Agricultural Detention Ponds Storm Sewer Network Performance		
Storm	Manholes Flooded	Storm Sewers at Over - Capacity
10 Year (74 mm)	41%	29%
25 Year (92 mm)	51%	33%
50 Year (106 mm)	58%	35%
100 Year (122 mm)	61%	37%
500 Year (164 mm)	67%	41%

4.5 Combination of Modifications and Agricultural Detention Ponds and Comparison of the Methods

Both *in situ* modifications and upstream detention ponds were combined together to determine the maximum achievable reduction. The purpose of these simulations was to show planners in Kalona the maximum possible flood reduction if they followed the designs presented in this thesis using the same techniques as described above. Figure 4-22, Figure 4-23, and Figure 4-24 show the maximum inundation for the 10 year, 100 year, and 500 year storms, respectively. Figure 4-25, Figure 4-26, and Figure 4-27 show the total flood reduction when compared to the base model for the 10, 100, and 500 year storms, respectively. APPENDIX E includes the inundation and total flood reduction maps for the 25 year and 50 year storms. The combined techniques relieved flooding in the 1st place, Pleasant View Circle, F Place, and E Place neighborhoods, as well as along both banks of Salvesen Creek and to the east of downtown. Downstream of the East Drainage Ditch culvert at E Avenue experienced increased flooding due to a higher culvert capacity.

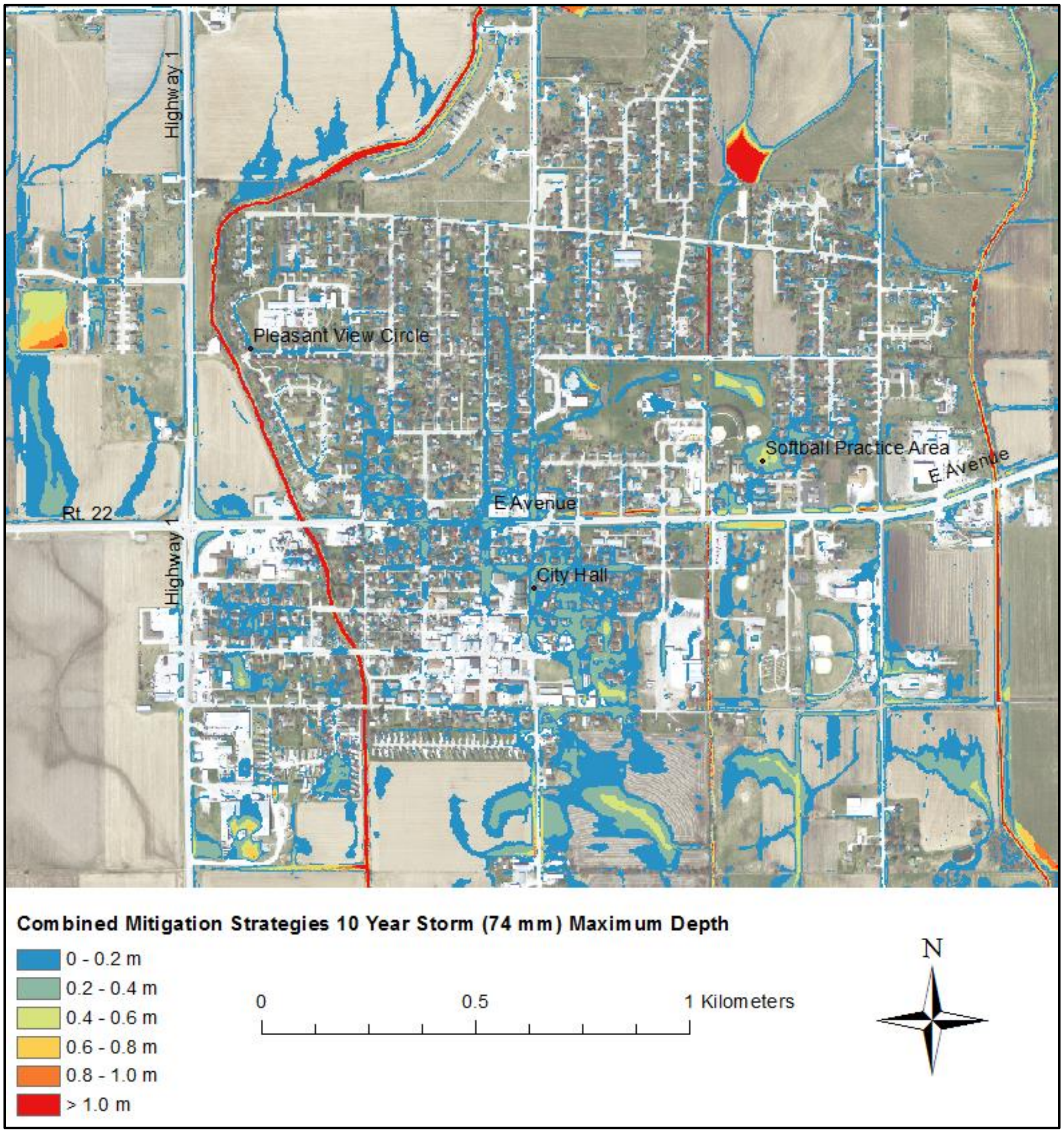


Figure 4-22: Maximum Depth for a 10 Year (74 mm) Storm with Combined Flood Reduction Techniques

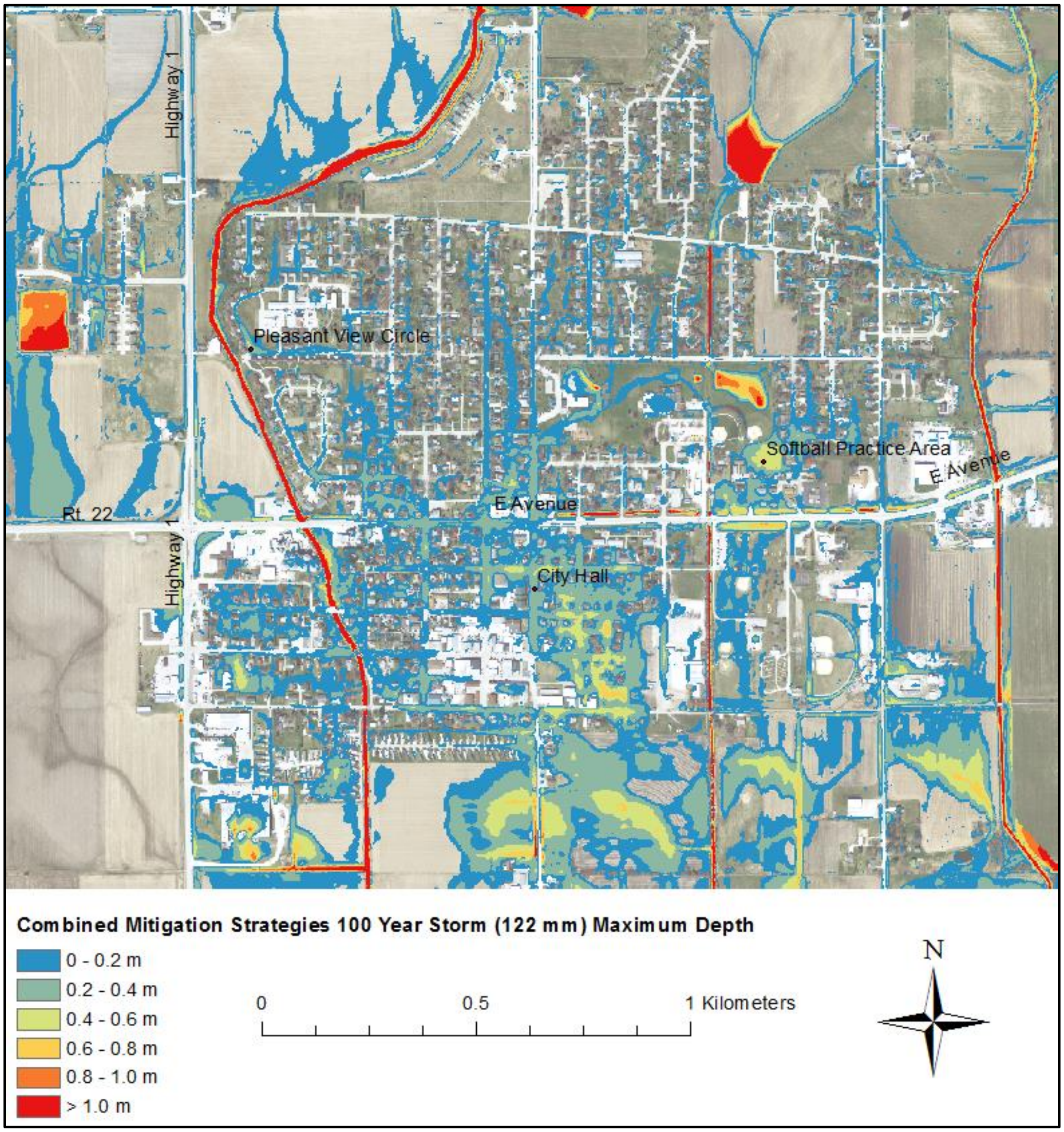


Figure 4-23: Maximum Depth for a 100 Year (122 mm) Storm with Combined Flood Reduction Techniques

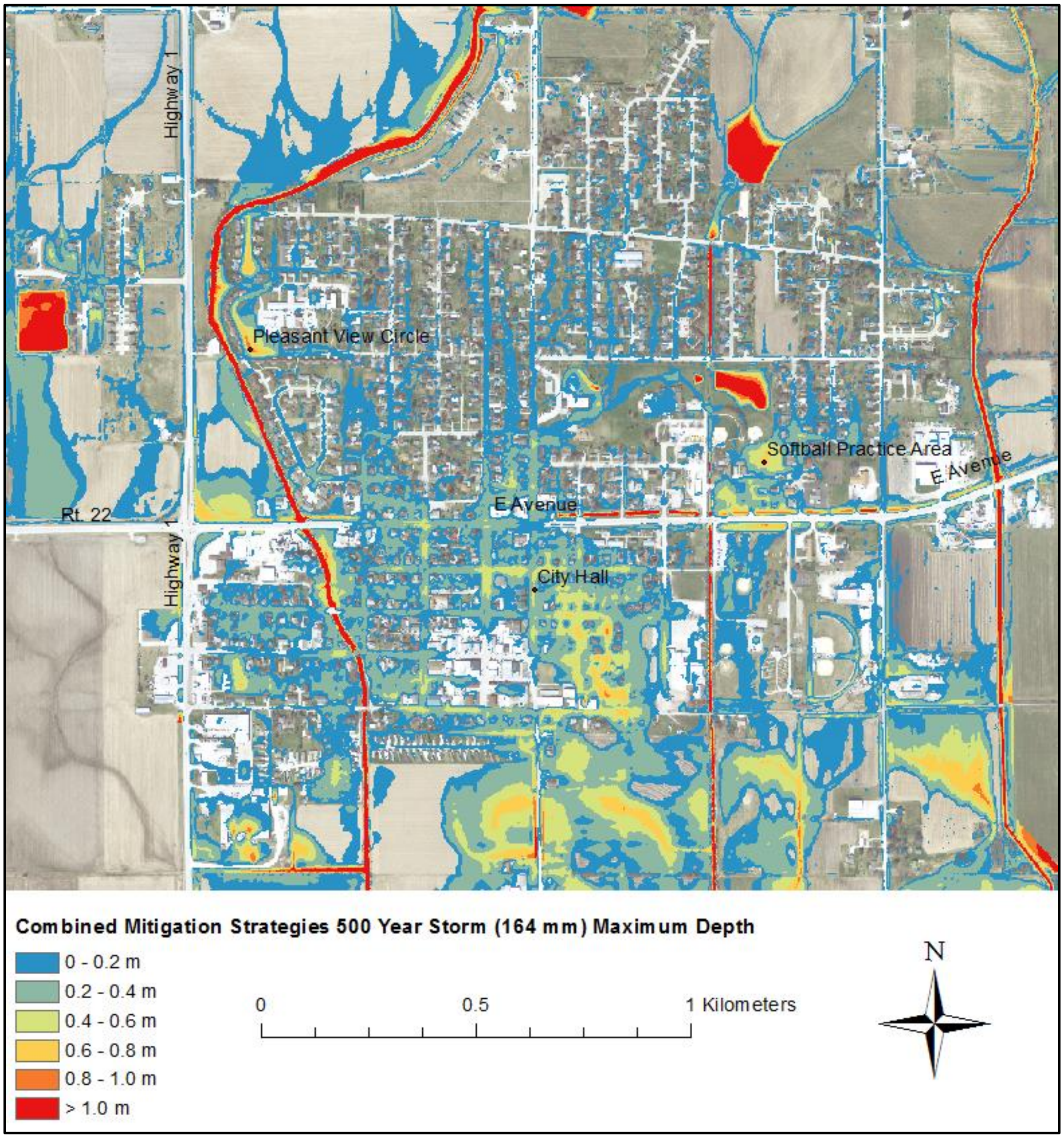


Figure 4-24: Maximum Depth for a 500 Year (164 mm) Storm with Combined Flood Reduction Techniques

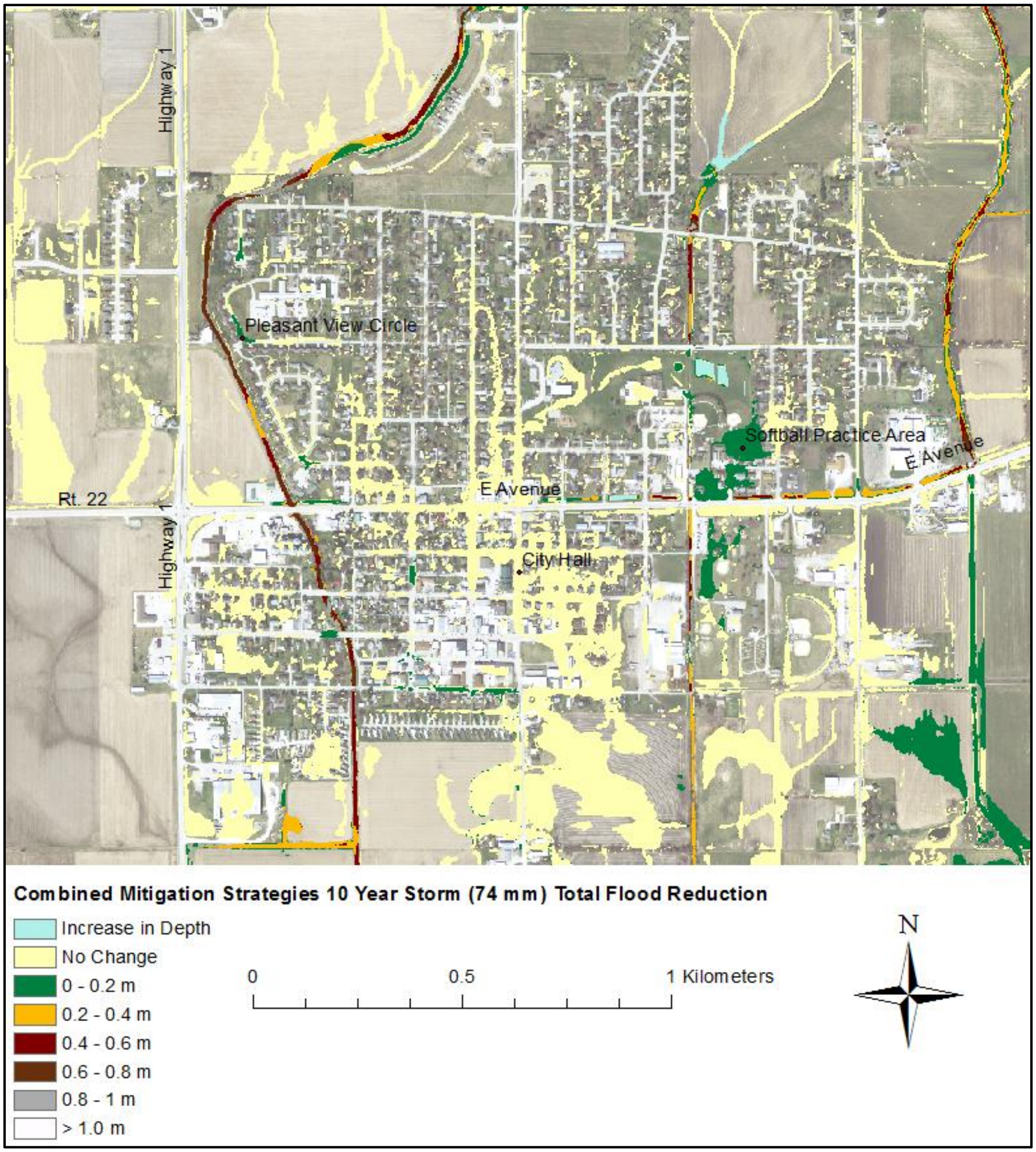


Figure 4-25: Total Flood Reduction for a 10 Year (74 mm) Storm with Combined Flood Reduction Techniques

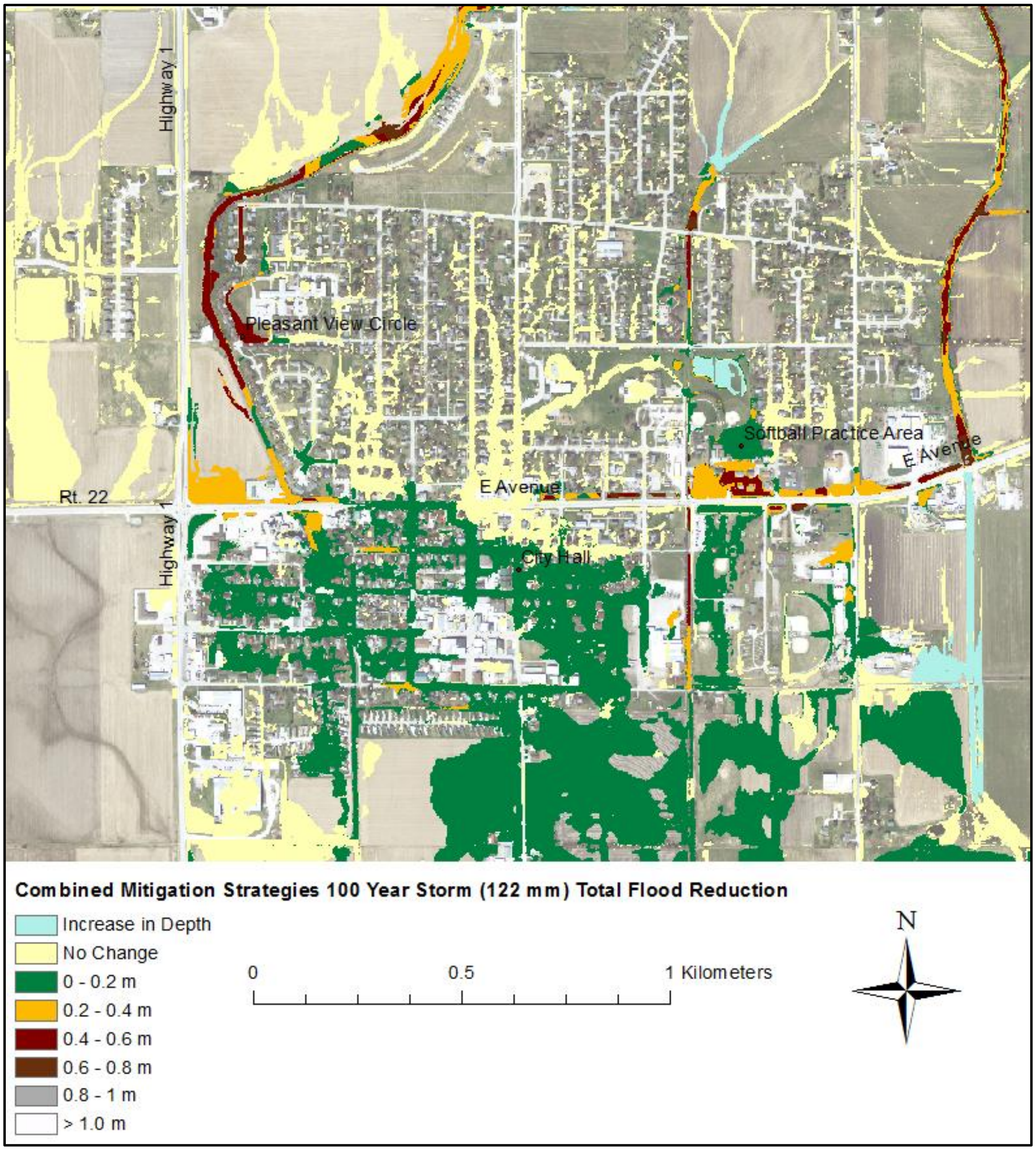


Figure 4-26: Total Flood Reduction for a 100 Year (122 mm) Storm with Combined Flood Reduction Techniques

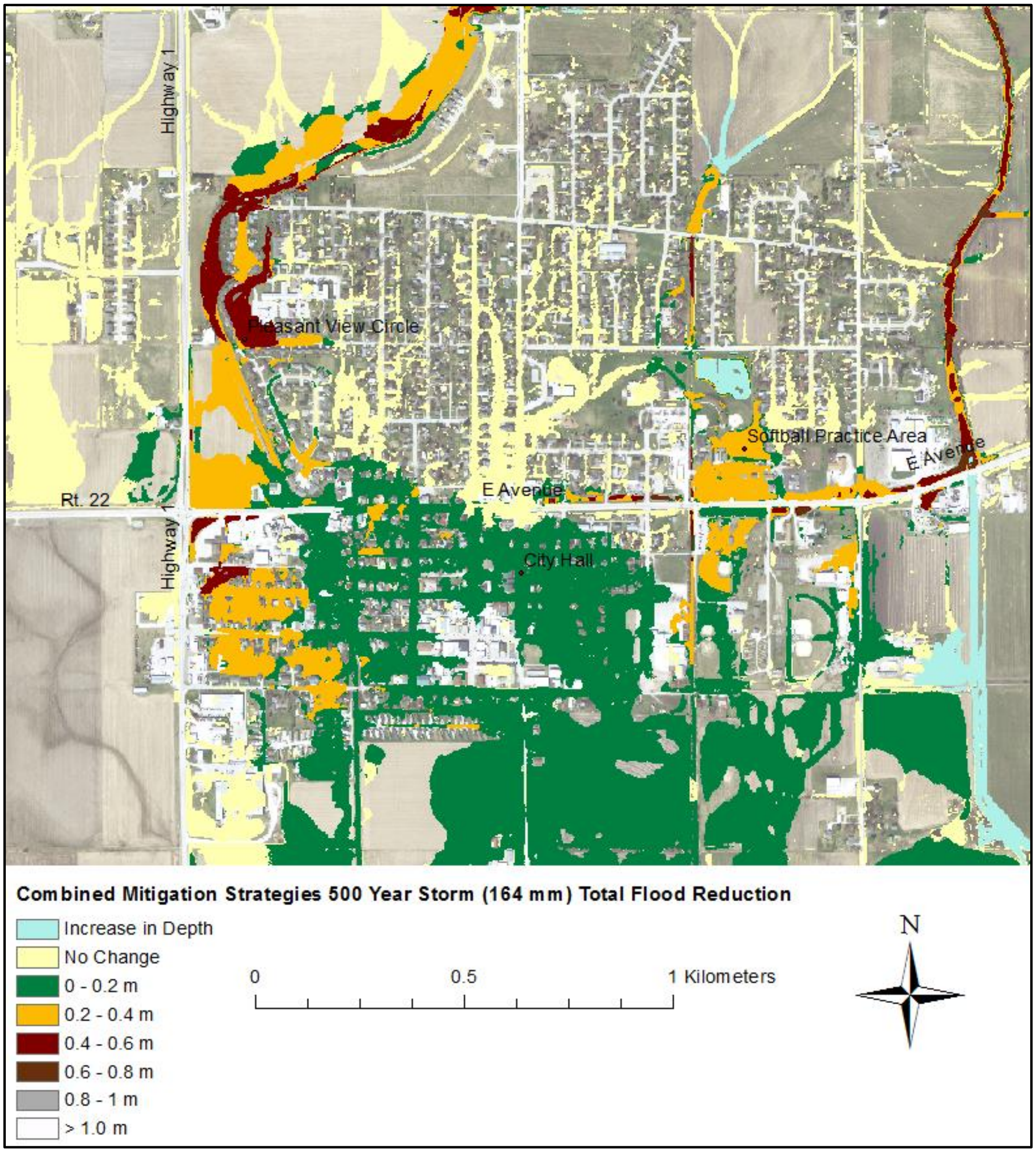


Figure 4-27: Total Flood Reduction for a 500 Year (164 mm) Storm with Combined Flood Reduction Techniques

Table 4-10 and Table 4-11 list the maximum depths at each index point and their percent reduction compared to the base model. When the flood mitigation methods were combined, the peak reduction at Pleasant View Circle occurred during the 50 year storm at 66%, and during the 500 year storm at both the Softball Practice Area and City Hall at 24% and 25%, respectively. The decrease in peak reduction at Pleasant View Circle is from an overload of the network due to local runoff from the east along H Avenue.

Table 4-10: Maximum Depths at Each Index Point using the Combined Mitigation Strategies

Combined Mitigation Strategies Maximum Depth (m)					
Index Point	10 Year Storm Depth (74 mm)	25 Year Storm Depth (92 mm)	50 Year Storm Depth (106 mm)	100 Year Storm Depth (122 mm)	500 Year Storm Depth (164 mm)
Pleasant View Circle	0.19	0.24	0.30	0.46	0.89
Softball Practice Area	0.50	0.54	0.57	0.60	0.66
City Hall	0.23	0.27	0.30	0.33	0.41

Table 4-11: Total Flood Reduction at each Index Point using the Combined Mitigation Strategies

Combined Mitigation Strategies Reduction					
Index Point	10 Year Storm Reduction (74 mm)	25 Year Storm Reduction (92 mm)	50 Year Storm Reduction (106 mm)	100 Year Storm Reduction (122 mm)	500 Year Storm Reduction (164 mm)
Pleasant View Circle	44%	62%	66%	55%	34%
Softball Practice Area	20%	22%	23%	23%	25%
City Hall	2%	2%	10%	17%	25%

Table 4-12 shows the storm sewer network performance using the combined techniques. The upstream detention ponds had a greater impact than the modifications, although there were improvements in the amount of manholes flooded for the 100 year and 500 year storms. The manholes which did not flood using the combination techniques during the 10 year storm were located just upstream of Salvesen Creek on D Avenue to the west and B Avenue to the East. The manholes which were flooded during the 500 year base storm but not during the combined techniques 500 year storm were along H Avenue to the west of the central drainage ditch. Due to less flow in the Central Drainage Ditch, the east-west main under H Avenue was able to carry more water because of decreased backflow effects and there was no overflow from the creek.

Table 4-12: Combined Mitigation Strategies Storm Sewer Network Performance

Combined Migitation Strategies Storm Sewer Network Performance		
Storm	Manholes Flooded	Storm Sewers at Over - Capacity
10 Year (74 mm)	41%	29%
25 Year (92 mm)	51%	32%
50 Year (106 mm)	57%	35%
100 Year (122 mm)	60%	37%
500 Year (164 mm)	66%	42%

Figure 4-28, Figure 4-29, and Figure 4-30 show the 10 year storm comparisons at Pleasant View Circle, the Softball Practice Area, and City Hall, respectively. At Pleasant View Circle, the base depth hydrograph had two peaks, at 1.2 hours and 1.9 hours, caused by local runoff and the upstream ponds decreased the maximum depth by 13%, while the modifications reduced flooding by 44%. Therefore, the modifications were more effective at reducing peak depths in this area during low flood events. The increased capacity of the network allowed the area to drain more quickly as well. Salvesen Creek did not overflow at J Avenue, meaning that the sewer modifications in the Pleasant View neighborhood were the primary reason for the flood reduction. The combined techniques also reduced the maximum depth by 44%. Therefore, the modeled modifications were more effective than upstream detention ponds.

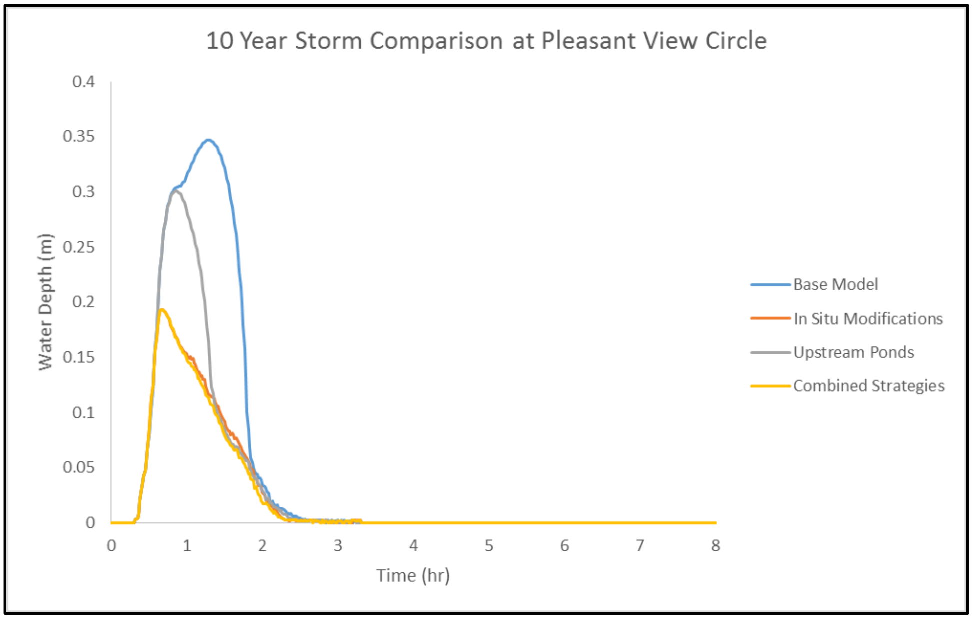


Figure 4-28: Comparison of Flood Reduction Methods for the 10Year (74 mm) Storm at Pleasant View Circle

The prototype inlet south of the softball practice fields is not located in the lowest part of the area. Therefore, the base model area did not drain properly and the only loss was due to infiltration. The added storm sewer inlet succeeded in completely draining the area. Because the dry detention basin north of the fields intercepted much of the water flowing into the area, while the upstream detention pond only reduced overflow from the Central Drainage Ditch, the *in situ* modifications provided more flood reduction than the upstream detention ponds with 18% to 9%, respectively. Combining the techniques reduced flooding by 20%. Therefore, combining the modifications with the ponds did not provide a significant increase in flood reduction. The dry detention basin and storm sewer modifications reduced flooding in this area more effectively during low flood than the pond north of the Central Drainage Ditch.

After the construction of the dry detention pond, floodwaters flowed southbound on 12th Street and 13th Street into the Softball Practice Area and then southwest around houses at the intersection of 12th Street and F Avenue, inundating the area. Further work could be done to reroute or mitigate flooding from this area.

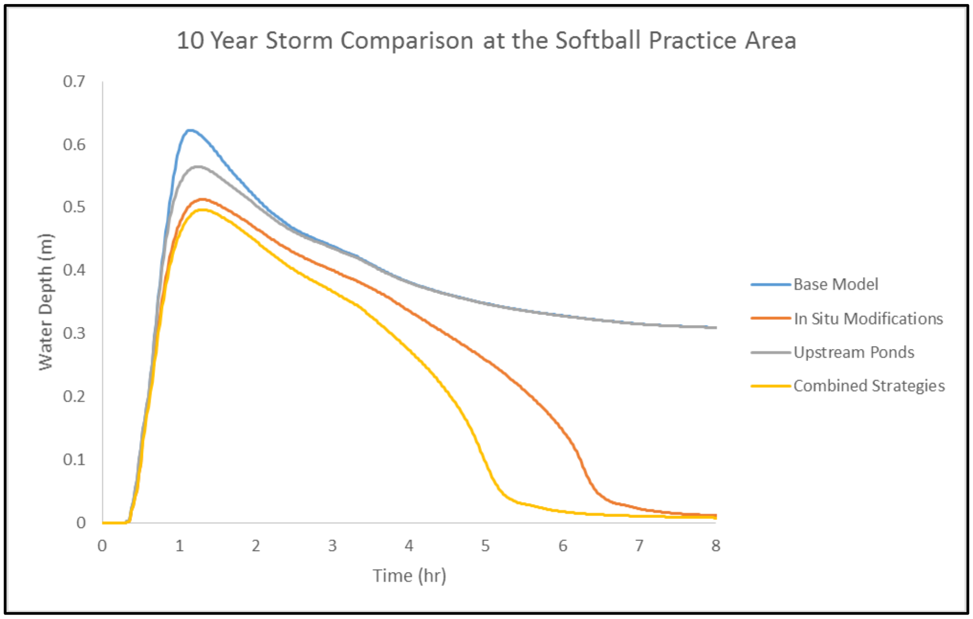


Figure 4-29: Comparison of Flood Reduction Methods for the
10 Year (74 mm) Storm at the Softball Practice Area

During low flood events in the City Hall area, the primary cause of flooding is local runoff instead of Salvesen Creek overflow; therefore, neither the ponds nor the modifications impacted flooding in City Hall during the low flood event.

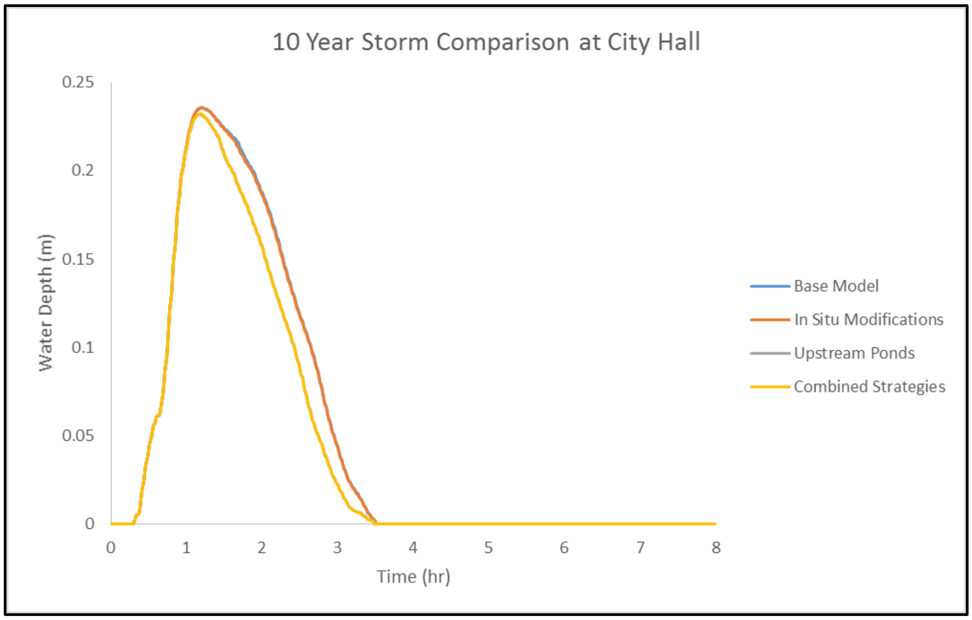


Figure 4-30: Comparison of Flood Reduction Methods for the
10 Year (74 mm) Storm at the City Hall

Figure 4-31, Figure 4-32, and Figure 4-33 show the comparison between the base model, *in situ* modifications, upstream ponds, and the combined techniques for Pleasant View Circle, the Softball Practice Area, and City Hall for the 100 year storm, respectively. At Pleasant View Circle, floodwaters overwhelmed the modifications which provided only 3% decrease in peak depth. The upstream ponds, however, provided a significant decrease in flooding, with a total reduction of 24%. When the two methods were combined, the total reduction was 55%. Therefore, the decrease in Salvesen Creek's peak flow due to the storage ponds increased the effectiveness of the *in situ* modifications. Even though the peak reduction was less than that with the upstream ponds, the increased capacity of the network drained the area more quickly. When the methods were combined, the decreased flow in Salvesen Creek provided additional capacity to the storm sewer network, as backflow effects were mitigated. Future work could concentrate on finding modifications which would become more effective due to the decreased backflow provided by the detention ponds, such as at Pleasant View Circle.

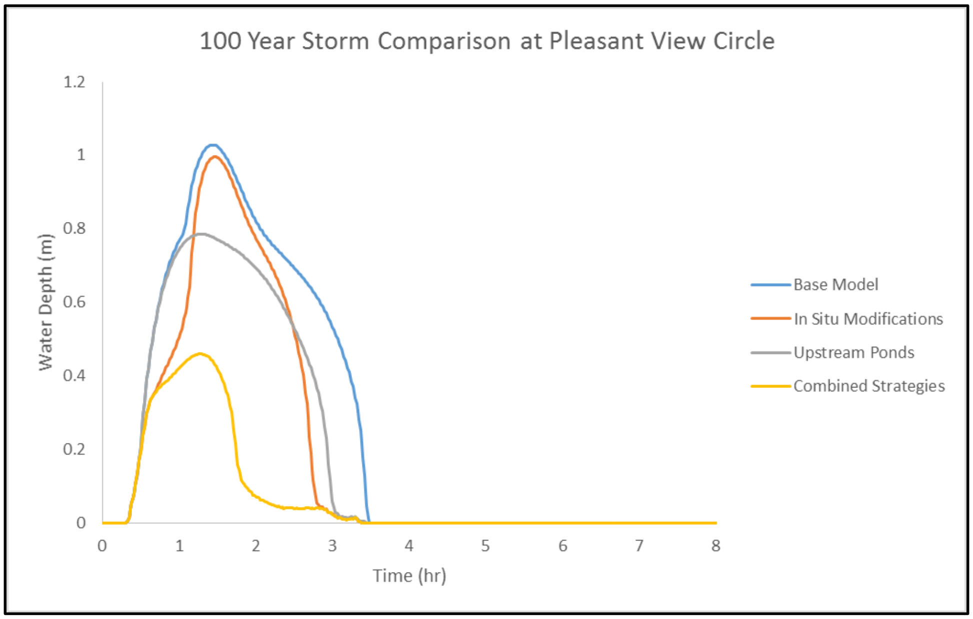


Figure 4-31: Comparison of Flood Reduction Methods for the 100 Year (122 mm) Storm at Pleasant View Circle

Comparable to the low flood condition, the Softball Practice Area did not completely drain throughout the simulation. Therefore, only the modifications allowed the area to return to a dry state. The modifications also reduced the peak depth by 22%, greater than the 14% reduction provided by the ponds. However, the dry detention basin north of the softball fields was over capacity during this storm, causing the second peak after 1.5 hours. Similar to the 10 year event, combining the techniques did not significantly improve upon the modifications.

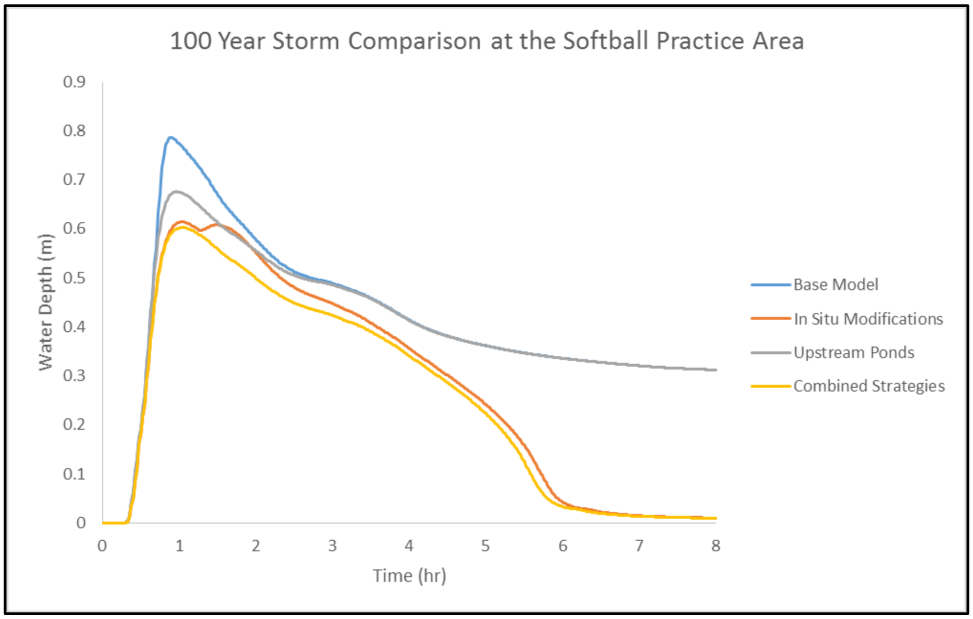


Figure 4-32: Comparison of Flood Reduction Methods for the 100 Year (122 mm) Storm at the Softball Practice Area

The *in situ* modifications reduced the peak depth at City Hall by a negligible 2%. Both the upstream ponds and the combined techniques reduced the peak depth by 17%. Therefore, the reduction at City Hall came from the upstream detention ponds. Similar to the low flood, the high flood conditions for the base and *in situ* modification models have 2 peaks, at 1.2 hours and 1.9 hours. The first peak was caused by local runoff, which was not impacted by the ponds. The second peak was caused by Salvesen Creek overflow, which was reduced.

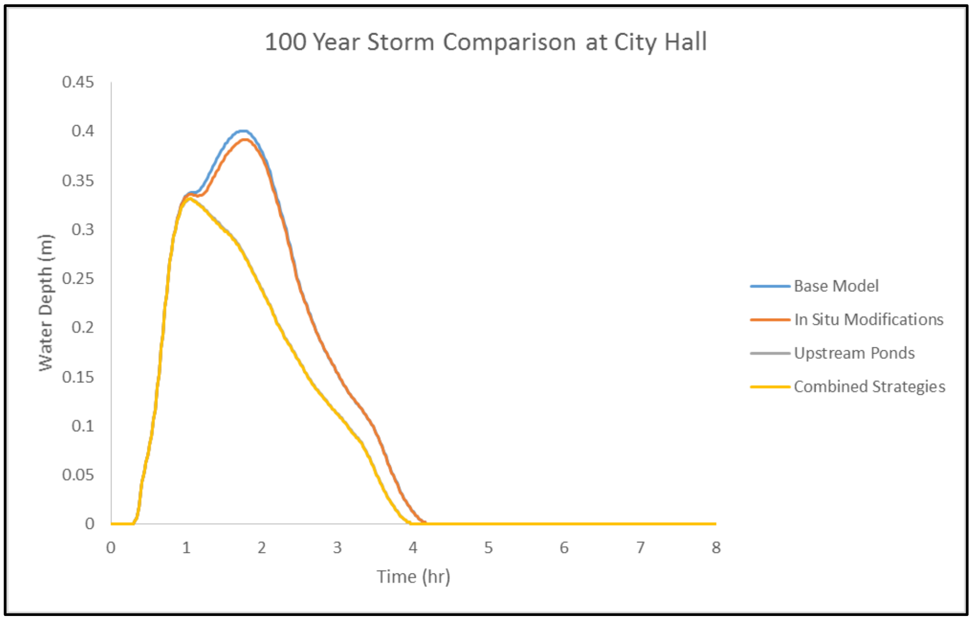


Figure 4-33: Comparison of Flood Reduction Methods for the
100 Year (122 mm) Storm at City Hall

Figure 4-34, Figure 4-35, and Figure 4-36 show the comparison between each model at Pleasant View Circle, the Softball Practice Area, and City Hall for the 500 year storm, respectively. Similar to the 100 year storm, modifications to the drainage network within Kalona were negligible during the 500 year event at Pleasant View Circle. This was because Salvesen Creek overflow and local runoff completely overwhelmed the network and the embankment at J Avenue. However, the increased capacity of the network helped drain the area more quickly after the peak. The upstream detention ponds reduced the peak depth by 32%, greater than the 24% during the 100 year event. The detention ponds were more effective at reducing peak flooding in areas with significant overflow and during high intensity events when the modifications became overwhelmed. The combined model had a peak depth reduction of 34%, greater than models using only the upstream detention ponds but less than the 100 year reduction. This pattern resembled the *in situ* modifications but still provided significant flood reduction. It also drained more quickly than the 500 year *in situ* modification model. Combining the two techniques gave the area the benefits of both, with it draining more quickly due to the increased sewer capacity and decreased backflow from Salvesen Creek.

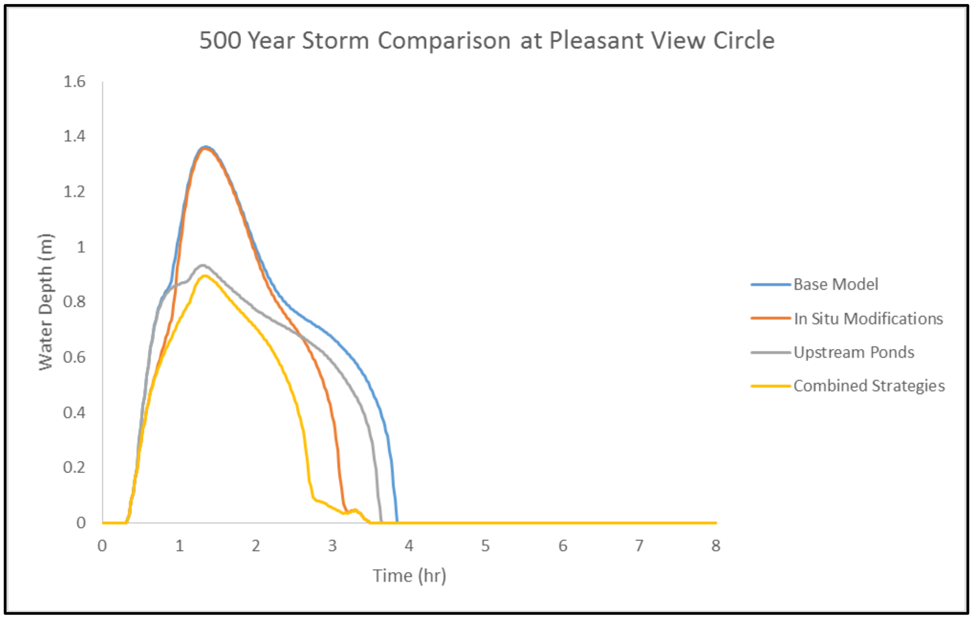


Figure 4-34: Comparison of Flood Reduction Methods for the 500 Year (164 mm) Storm at Pleasant View Circle

The effectiveness of both the *in situ* modifications and the upstream detention ponds in the Softball Practice Area decreased between the 100 year and 500 year storms from 22% to 11% and then 14% to 13%, respectively. Both the upstream agricultural detention ponds and the dry detention basin were over capacity. However, the effectiveness of the combined techniques increased from 23% to 24%. The added storage from the detention pond north of the Central Drainage Ditch allowed the detention basin north of the Softball Practice Area to intercept more local runoff. Even though it was overflowing during the 100 year event without the pond, it was still under-capacity during the 500 year event. Therefore, local runoff from other sources causes flooding in the area.

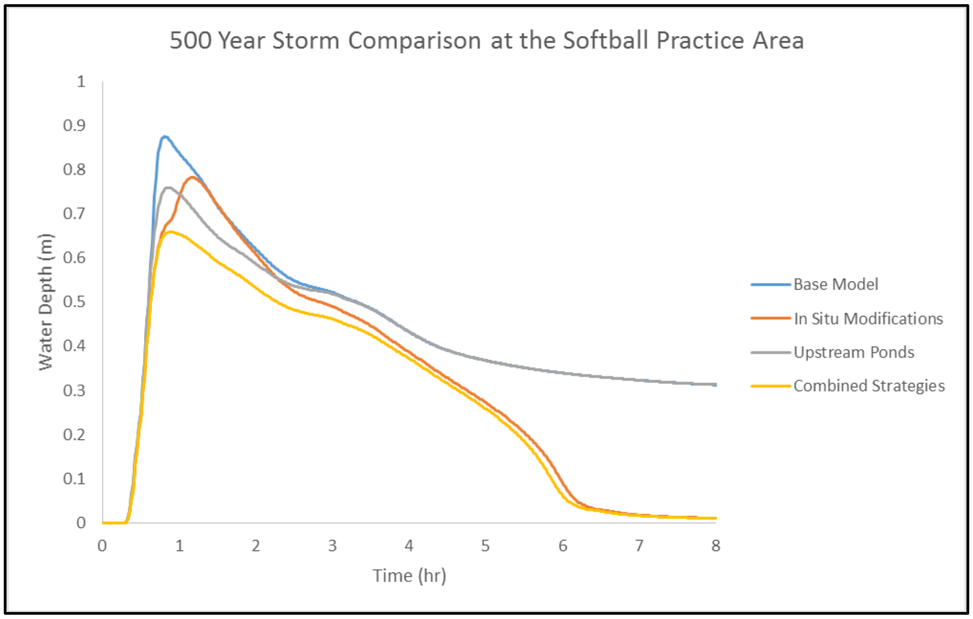


Figure 4-35: Comparison of Flood Reduction Methods for the 500 Year (164 mm) Storm at the Softball Practice Area

Similar to previous models, the *in situ* flood mitigation techniques provided no discernable benefit to City Hall. The only reduction in flooding came with the upstream detention basins. The upstream ponds and combined methods decreased flooding by 24% and 25%, respectively, an increase from 17% during the 100 year event. Further research could detect modifications which, when combined with the upstream detention ponds, would further reduce flooding in this area.

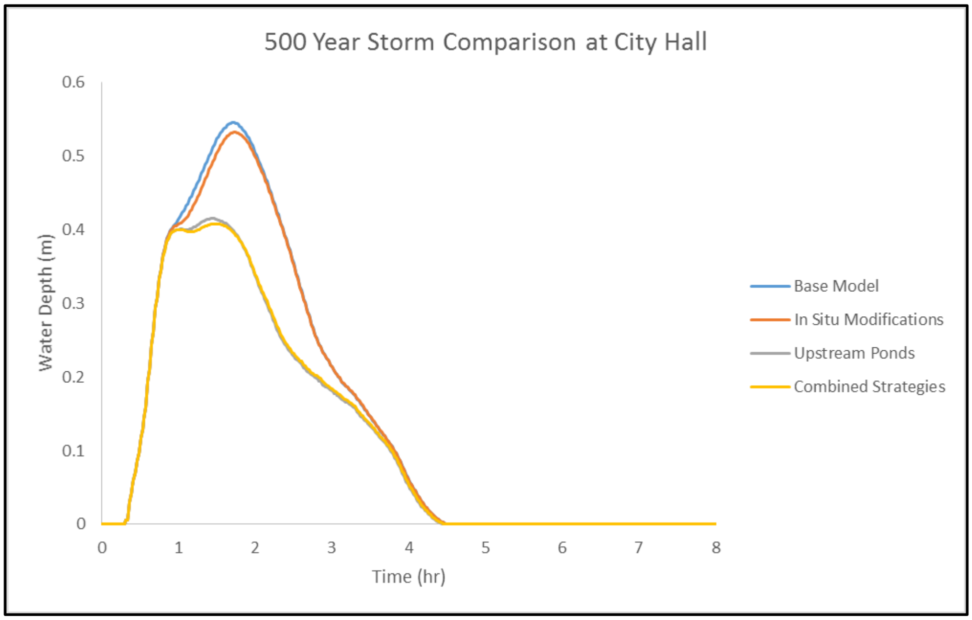


Figure 4-36: Comparison of Flood Reduction Methods for the 500 Year (164 mm) Storm at City Hall

CHAPTER 5. CONCLUSION

From multi-billion dollar disasters such as the flood to strike Cedar Rapids and Iowa City in 2008 to minor flash floods which occur over the course of hours, communities across Iowa face increasing challenges due to floods. Therefore, the Iowa Flood Center, Watershed Management Authorities across the state, local governments, and other organizations are working together to help mitigate the impact of flooding. Various modifications to the storm sewer network and a distributed storm water storage system of detention ponds for the town of Kalona were proposed and modeled using XPSWMM to test their ability to reduce flooding. It was found that in areas where the principal cause of flooding is stream overflow, the detention ponds provided the most reduction, while *in situ* modifications were more effective in areas where the cause is local runoff. Storm sewer modifications provided more relief during low flood events, while ponds decreased peak depth during high floods. *In situ* modifications were more effective at reducing flooding in the Softball Practice Area and ponds were more effective for City Hall. Ponds and modifications complemented each other in areas such as Pleasant View Circle, where the decreased flow in Salvesen Creek allowed the modified storm sewers to drain a larger volume more quickly than when the techniques were modeled separately.

Future work should focus on two distinct areas: data collection and monitoring, and further flood mitigation strategies. Ultimate confidence in the model will always be lacking without proper calibration or validation. Therefore, a system of rain gauges, stream gauges, or high water elevations during flood events would provide the data necessary for calibration and validation.

Additional flood mitigation techniques to be analyzed with this or future models could include levees, embankments, pump stations, further storm sewer modifications, and supplemental channels. Pump stations and storm sewer modifications along E Avenue could capture more local runoff, relieving neighborhoods north and east of downtown. Levees along Salvesen Creek could prevent overflow between E Avenue and A Avenue. Central Drainage Ditch bridge and pipe expansions between H Avenue and E Avenue could increase capacity and reduce overflow into the softball practice area. Additional channels through City Park or expanded roadside drainage ditches could reroute water away from the creeks and into the floodplain, increasing capacity in the ditches or reducing backflow on the storm sewer system.

Furthermore, since the model simulated the *in situ* modifications and upstream agricultural detention ponds as more effective together than individually at Pleasant View Circle and the Softball Practice Area, work should be taken to find other areas with similar results. For example, the capacity of the sewers under D Avenue, C Avenue, and B Avenue west of Salvesen Creek could be increased with reduced backflow. This model can be used to determine the effect of proposed developments as well. For instance, city administrators can determine how additional neighborhoods impacted downstream areas or the benefit of certain pipe sizes during road reconstruction projects.

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APPENDIX A. COMPARISON BETWEEN MIKE 11/21 AND XPSWMM WITH HEC-HMS INPUTS

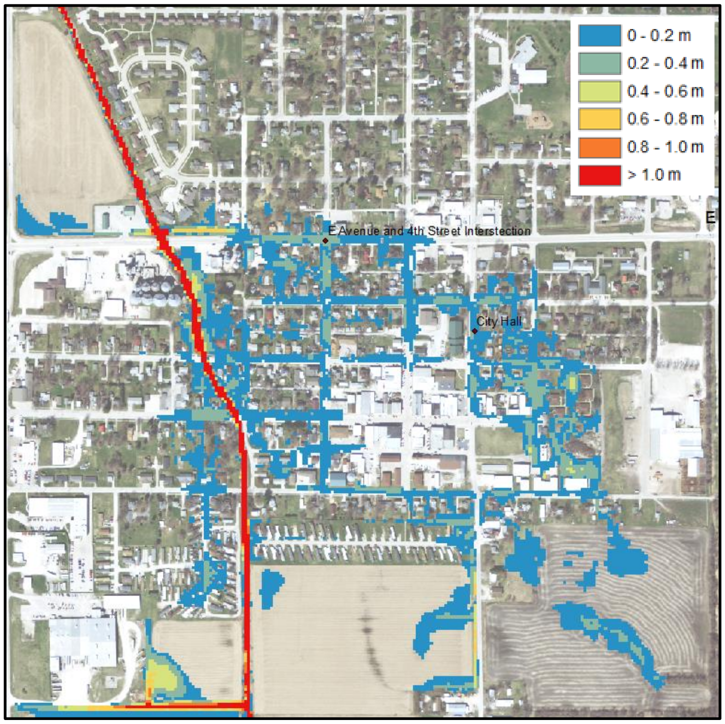

Figure A-1: MIKE 11/21 with HEC-HMS Inputs 50 Year (106 mm) Storm Inundation Map

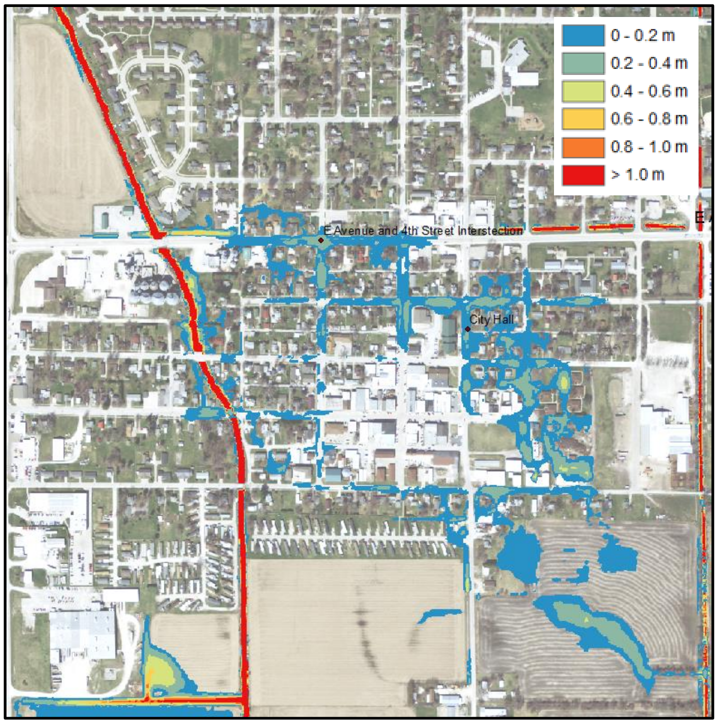

Figure A-2: XPSWMM with HEC-HMS Inputs 50 Year (106 mm) Storm Inundation Map

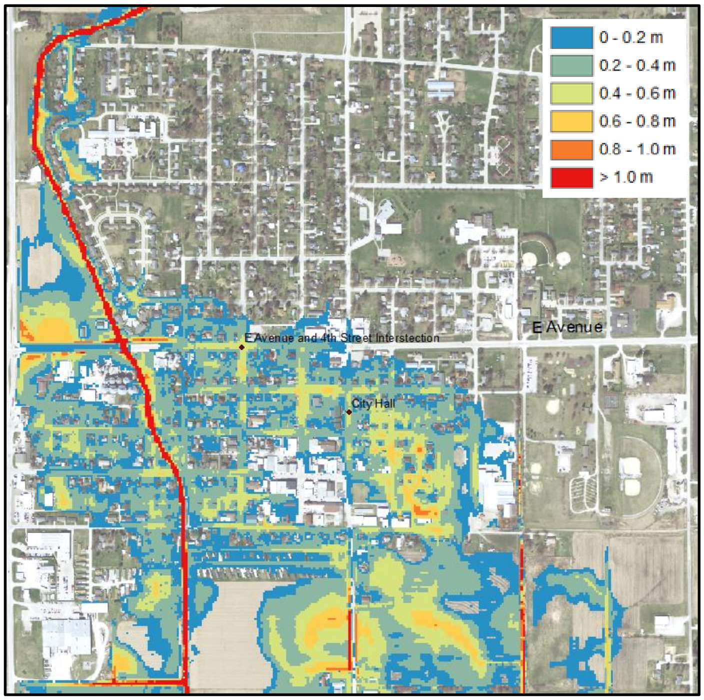

Figure A-3: MIKE 11/21 with HEC-HMS Inputs 500 Year (164 mm) Storm Inundation Map

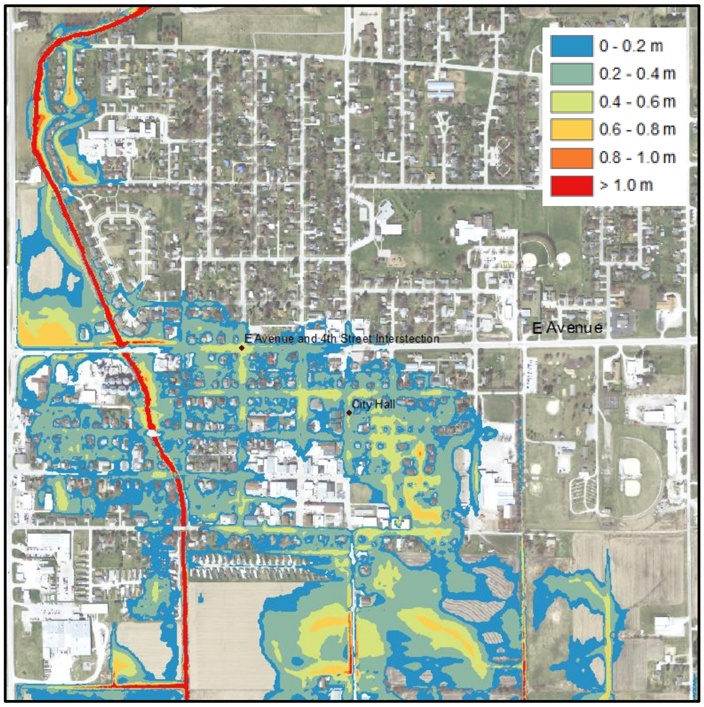

Figure A-4: XPSWMM with HEC-HMS Inputs 500 Year (164 mm) Storm Inundation Map

APPENDIX B. BASE 25 YEAR AND 50 YEAR STORMS

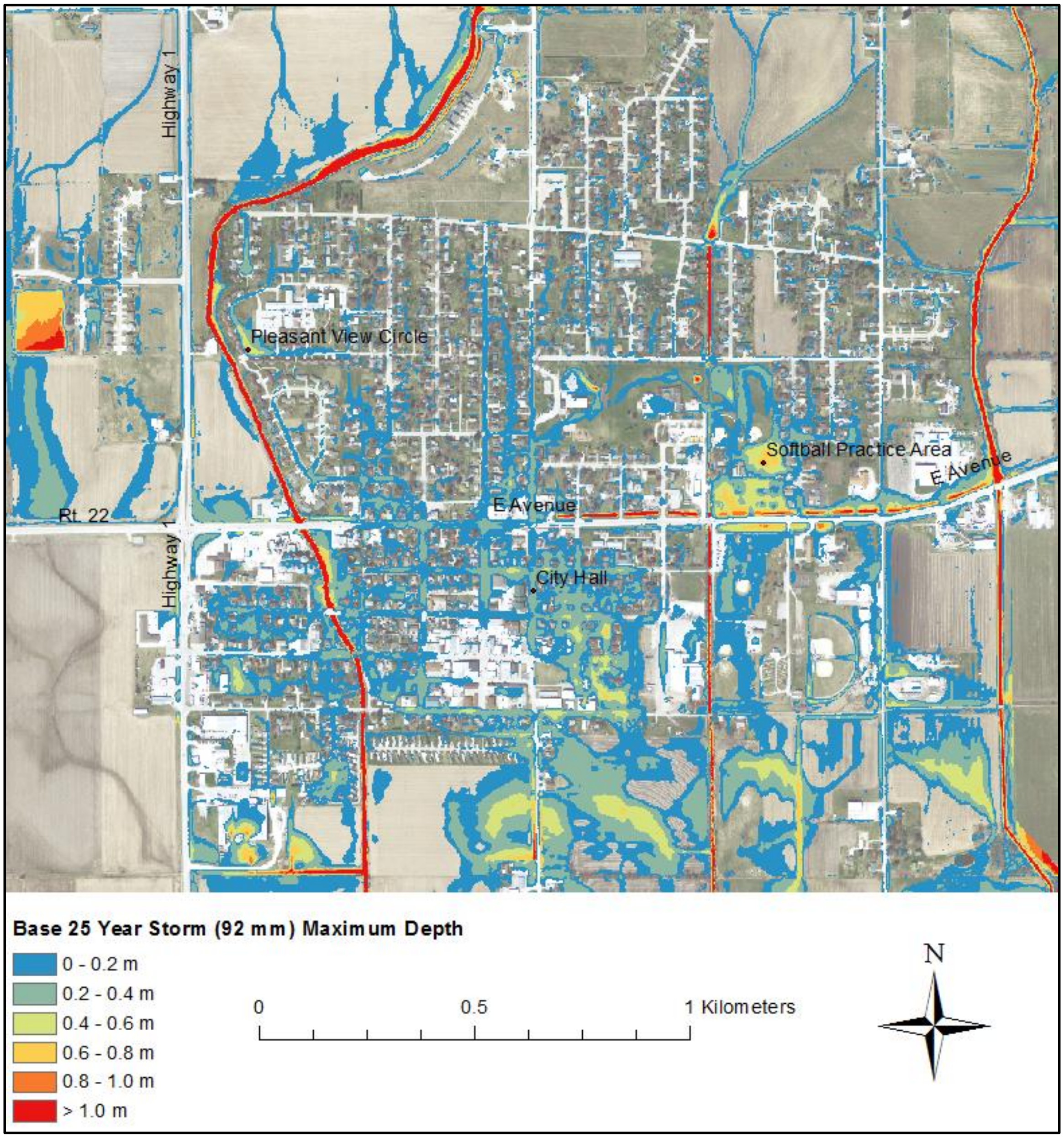

Figure B-1: Maximum Depth for a Base 25 Year (92 mm) Storm

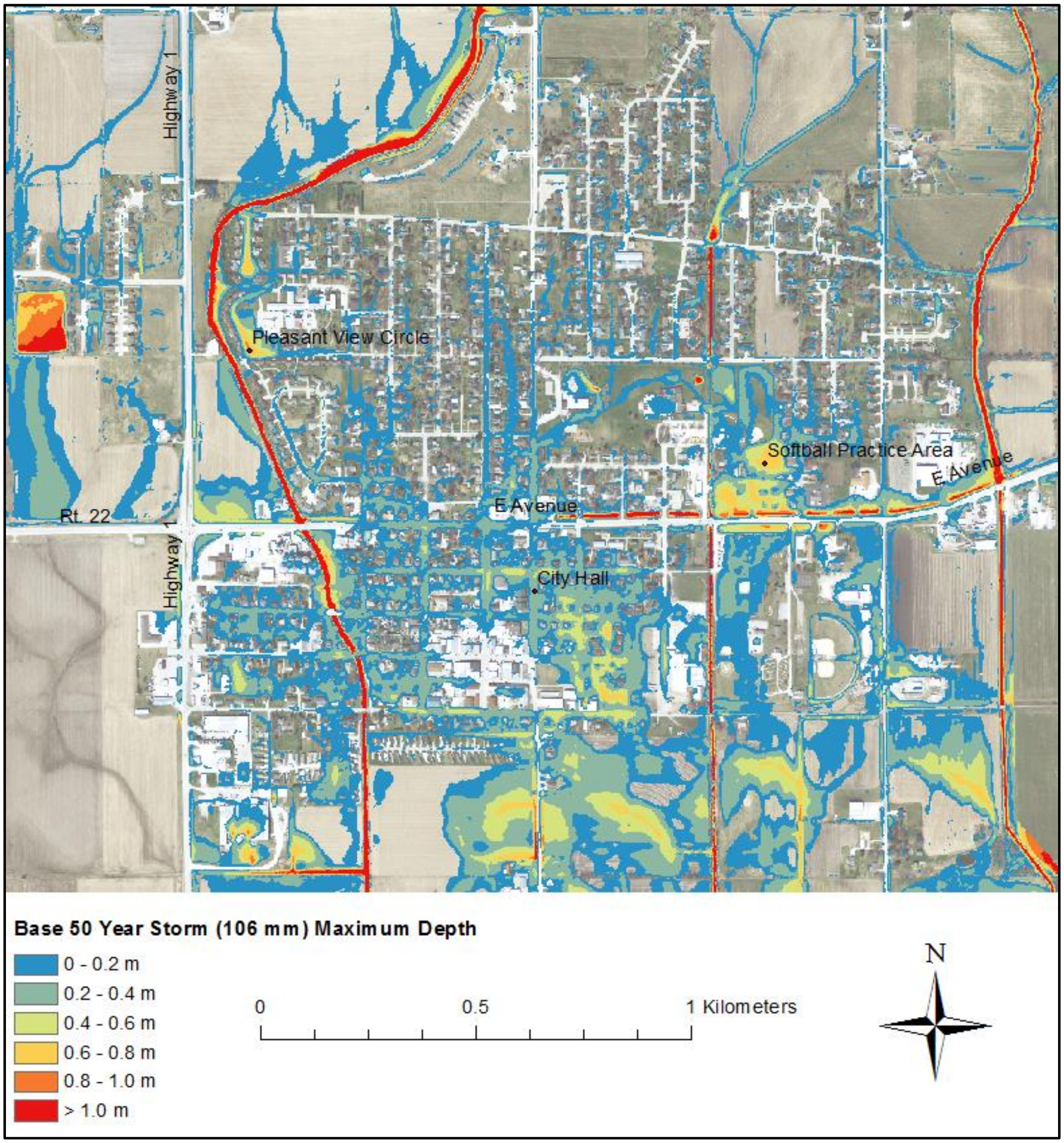

Figure B-2: Maximum Depth for a Base 50 Year (106 mm) Storm

APPENDIX C. *IN SITU* MODIFICATIONS 25 YEAR AND 50 YEAR STORMS

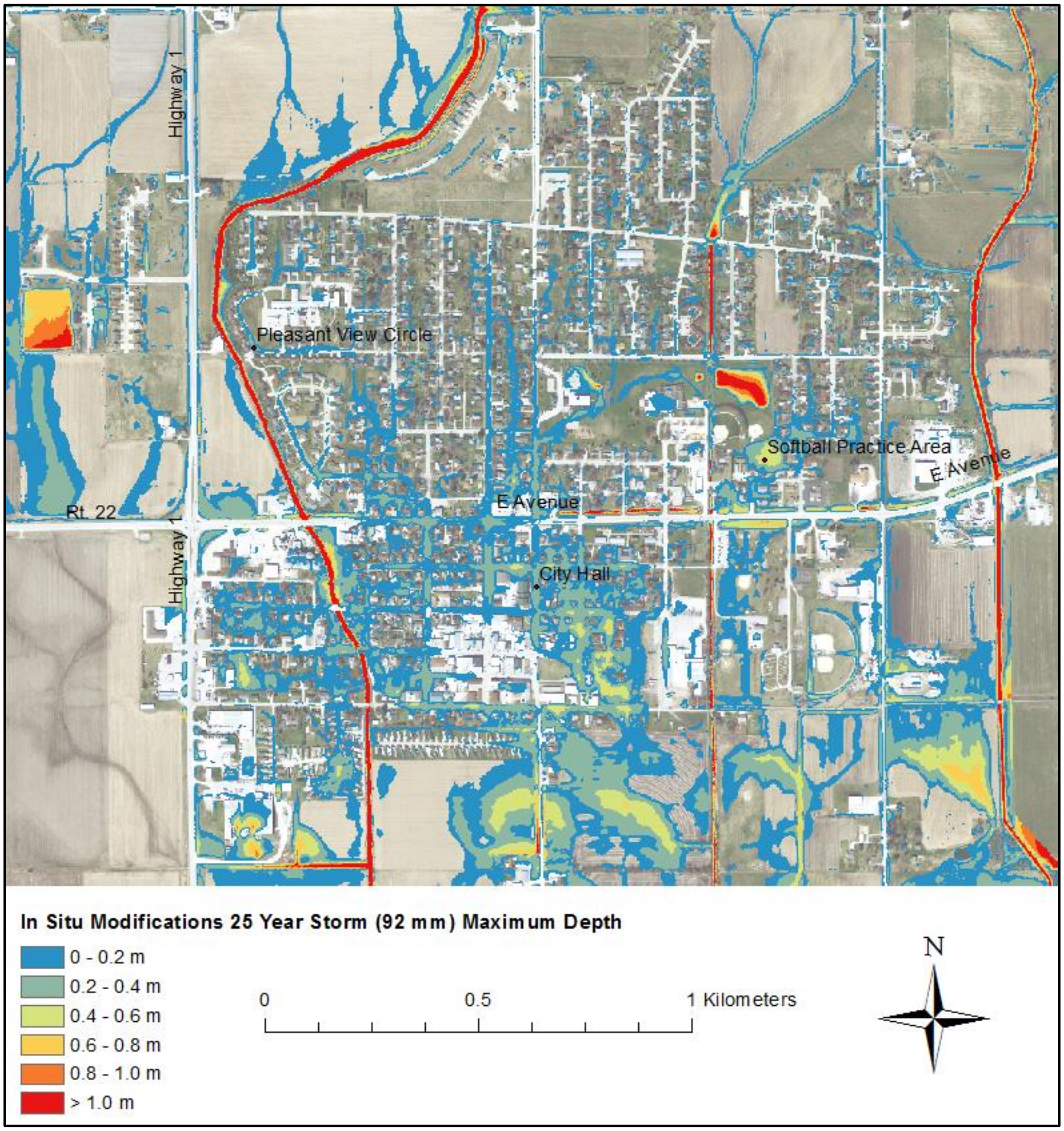

Figure C-1: Maximum Depth for a 25 Year (92 mm) Storm with *In Situ* Modifications Flood Reduction Techniques

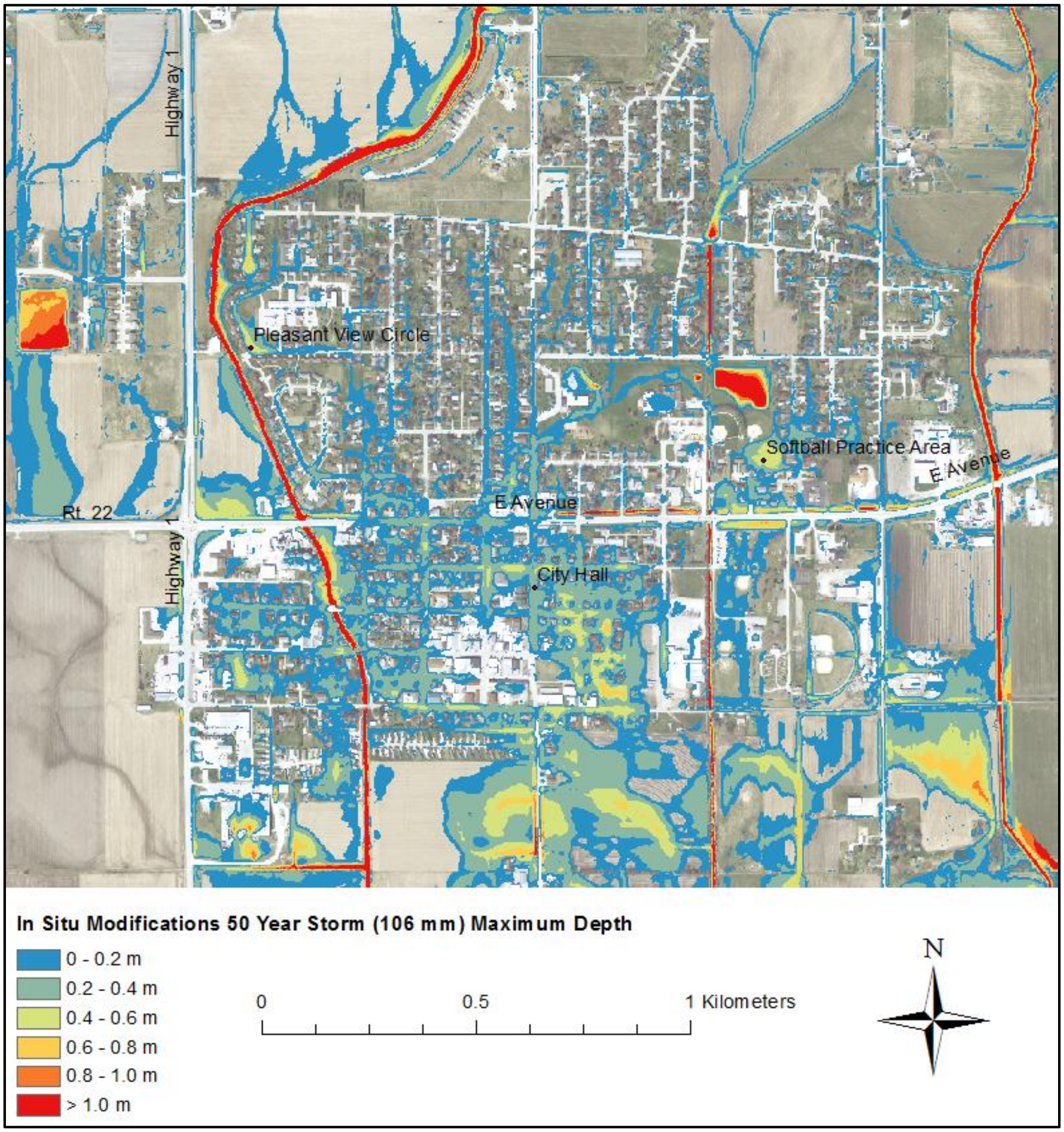

Figure C-2: Maximum Depth for a 50 Year (106 mm) Storm with *In Situ* Modifications Flood Reduction Techniques

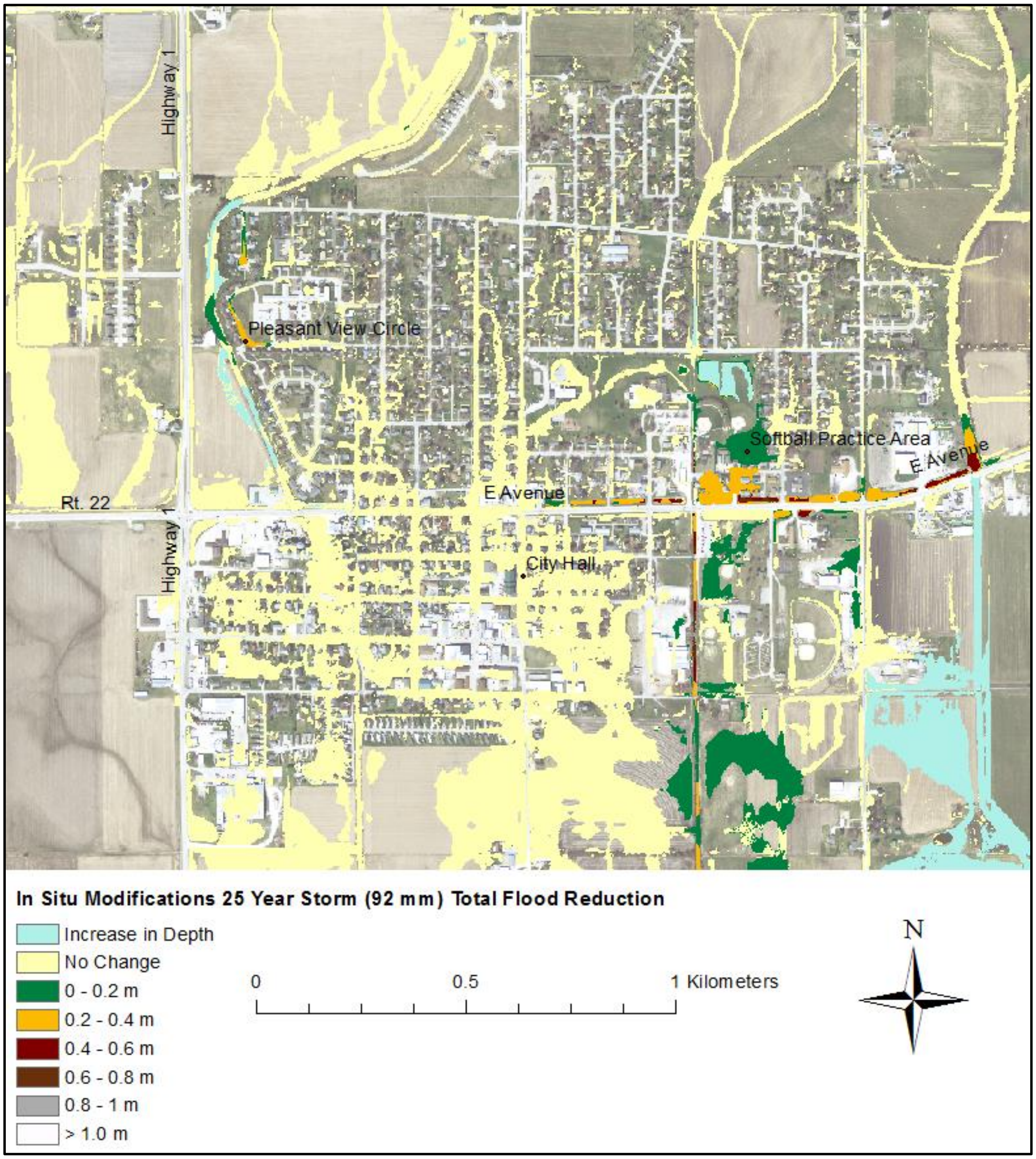

Figure C-3: Total Flood Reduction for a 25 Year (92 mm) Storm with *In Situ* Modification Flood Mitigation Techniques

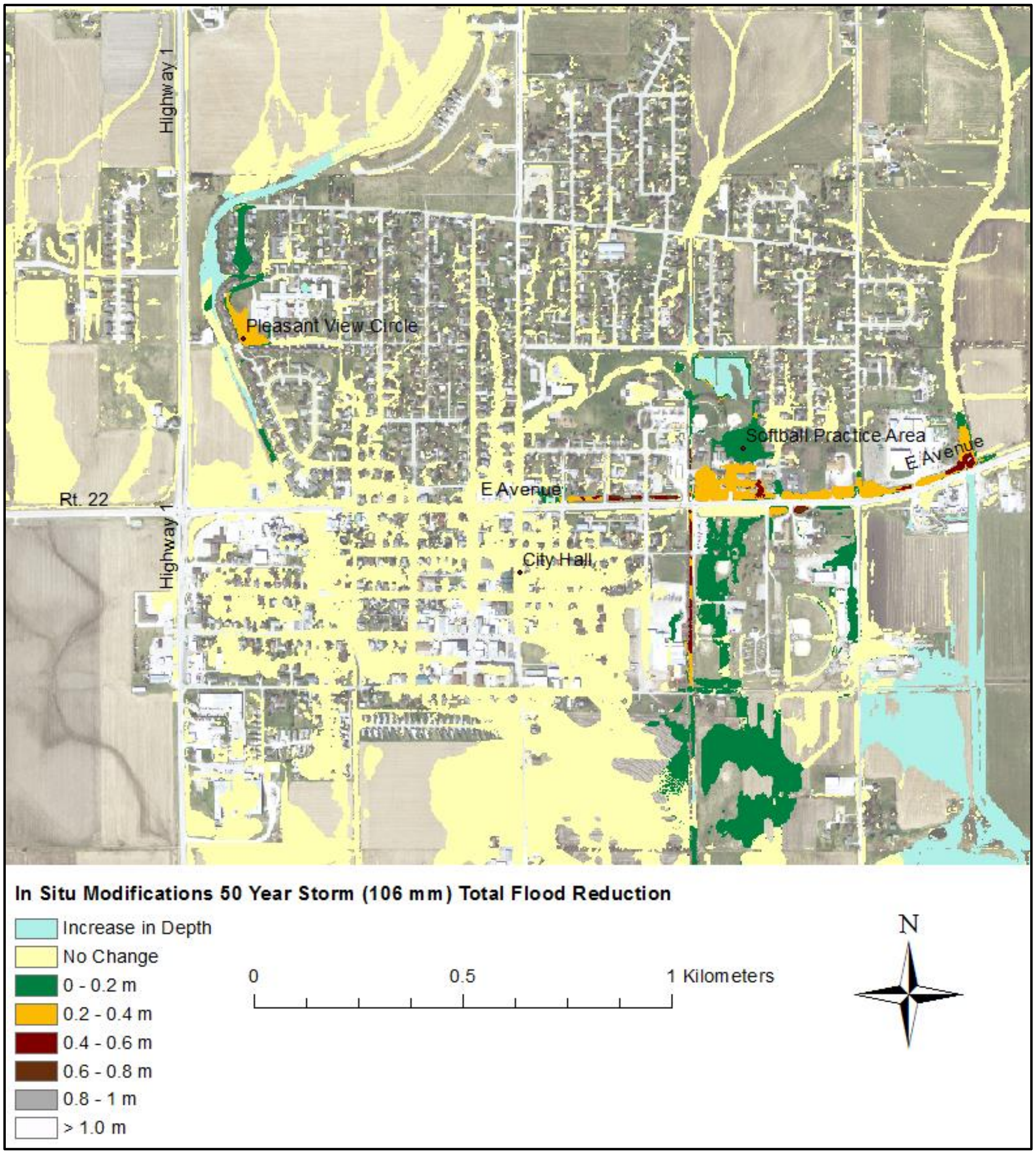

Figure C-4: Total Flood Reduction for a 50 Year (106 mm) Storm with *In Situ* Modification Flood Mitigation Techniques

APPENDIX D. UPSTREAM DETENTION PONDS 25 AND 50 YEAR STORMS

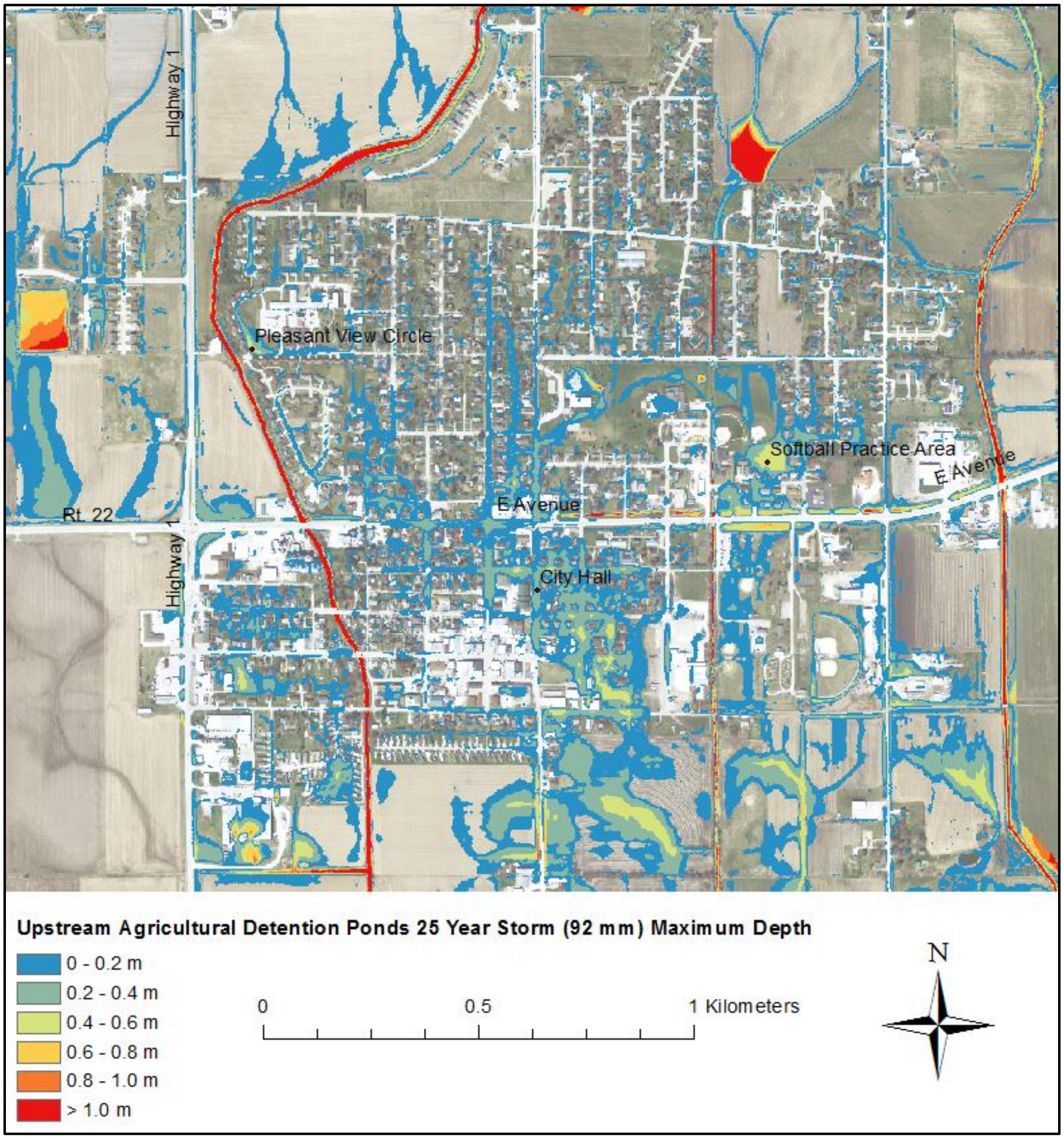

Figure D-1: Maximum Depth 25 Year (92 mm) Storm with Upstream Agricultural Detention Ponds Flood Reduction Technique

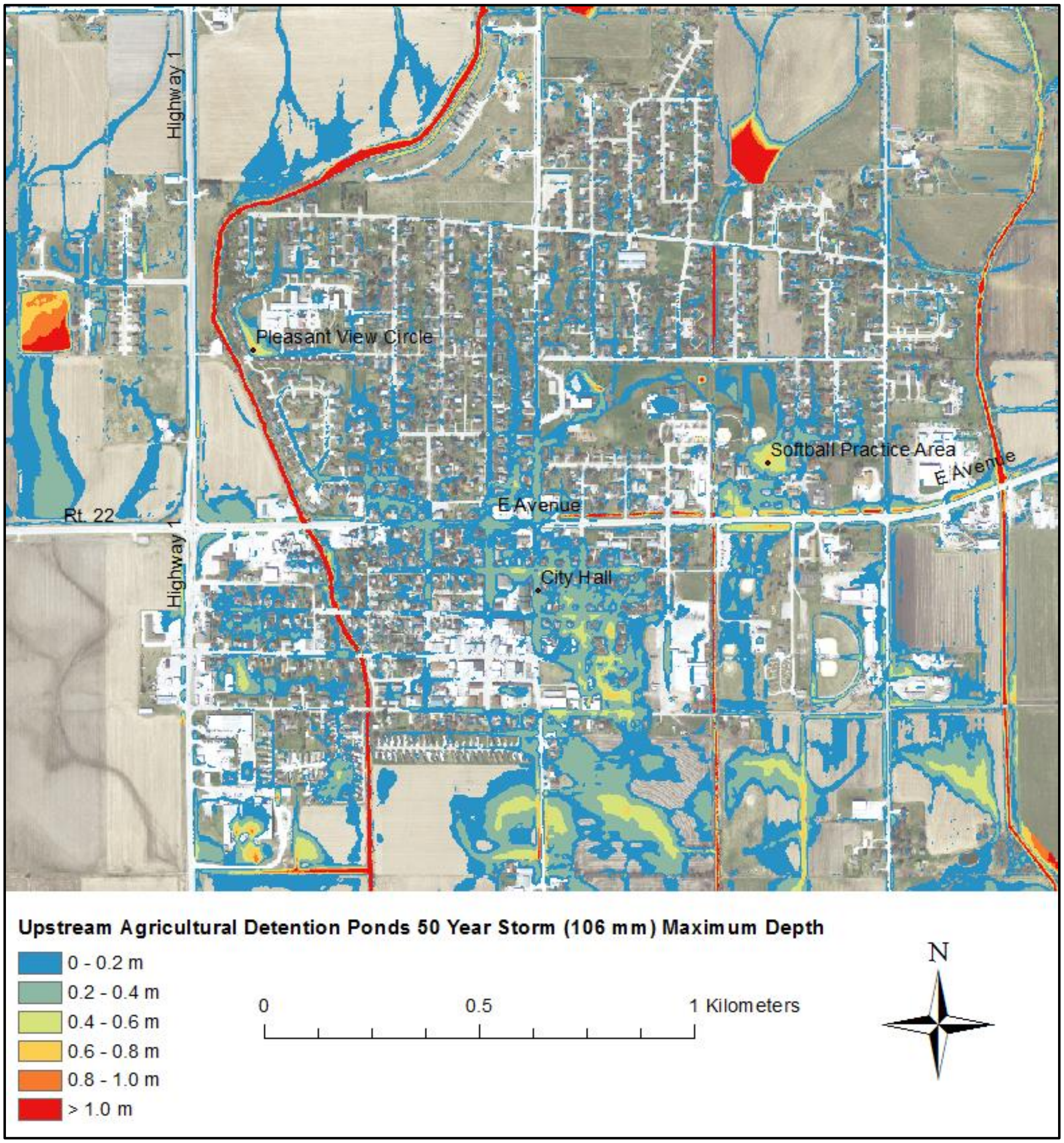

Figure D-2: Maximum Depth for a 50 Year (106 mm) Storm with Upstream Agricultural Detention Ponds Flood Reduction Technique

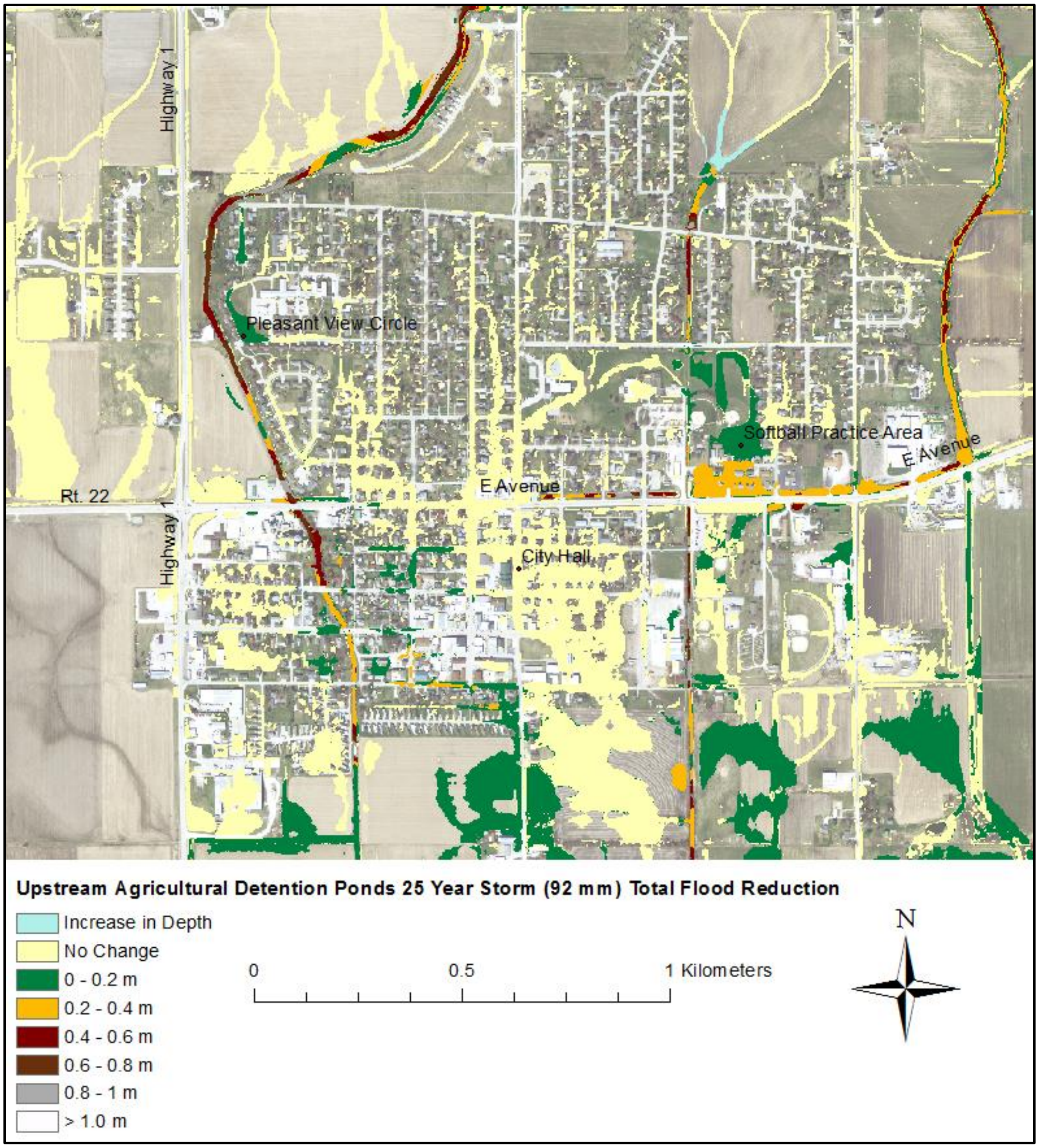

Figure D-3: Total Flood Reduction for a 25 Year (92 mm) Storm with Upstream Agricultural Detention Ponds

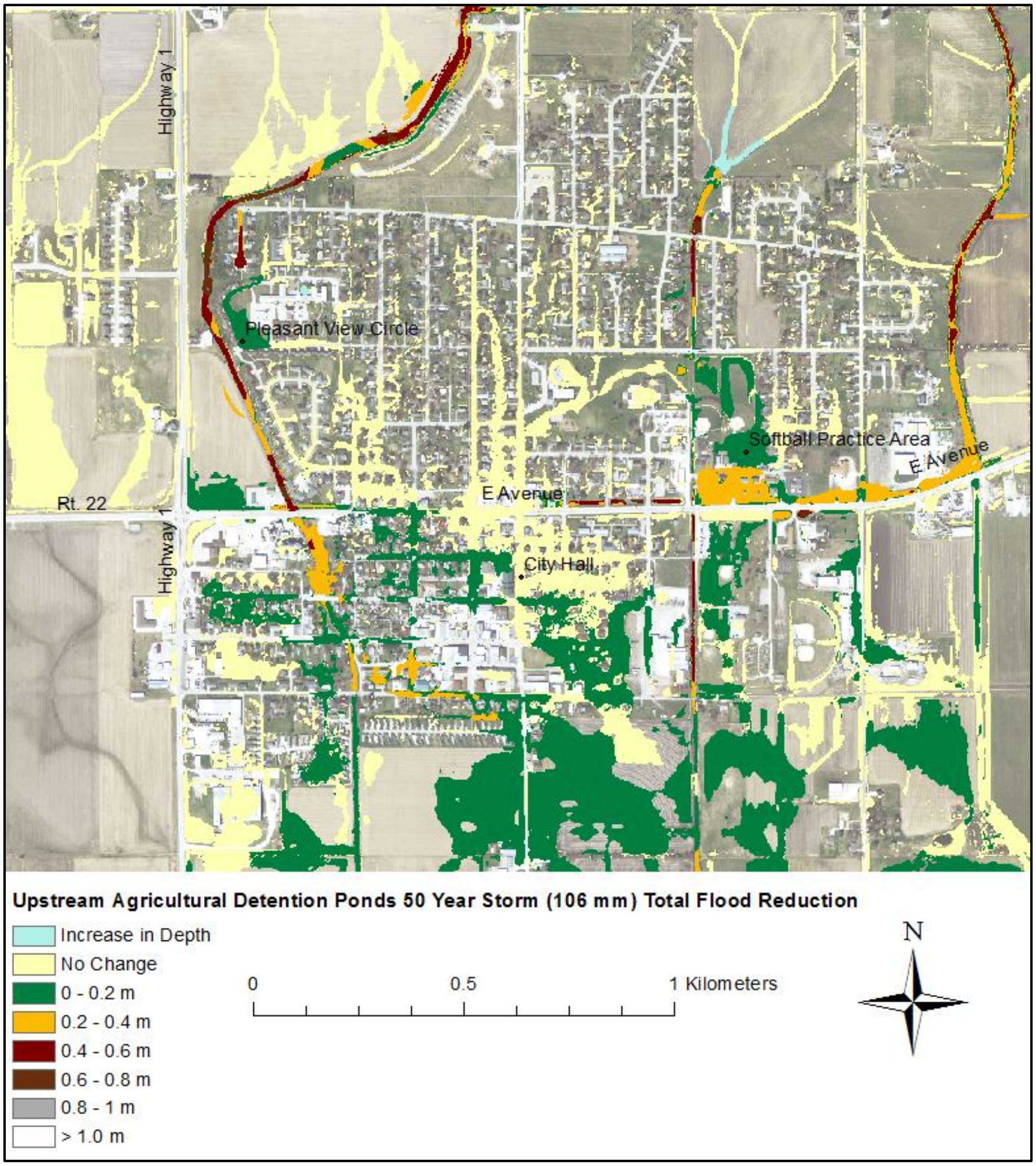

Figure D-4: Total Flood Reduction for a 50 Year (106 mm) Storm with Upstream Agricultural Detention Ponds

APPENDIX E. COMBINATION OF UPSTREAM DETENTION PONDS AND *IN SITU* MODIFICATIONS 25 YEAR AND 50 YEAR STORMS

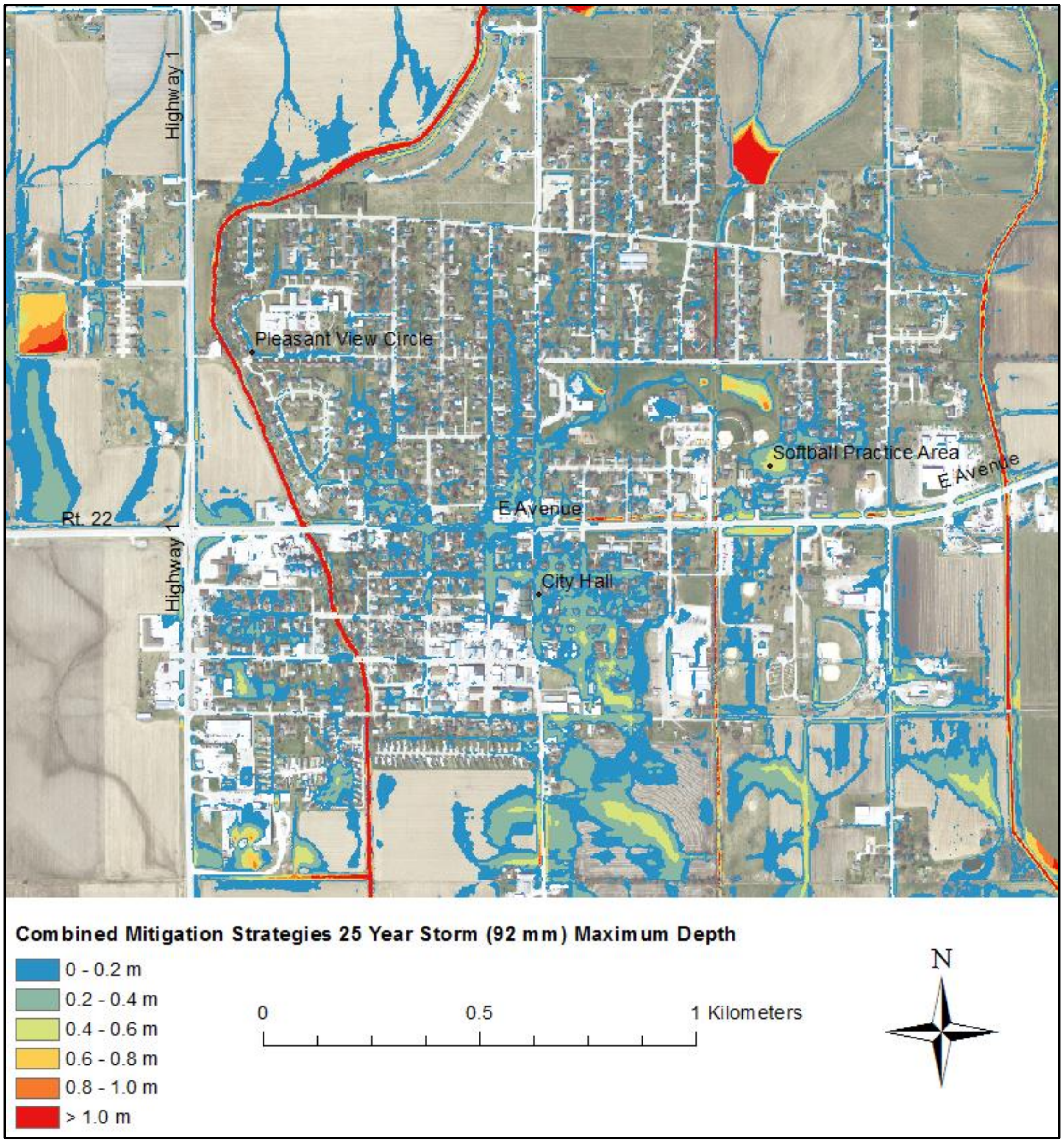

Figure E-1: Maximum Depth for a 25 Year (92 mm) Storm with Combined Flood Reduction Techniques

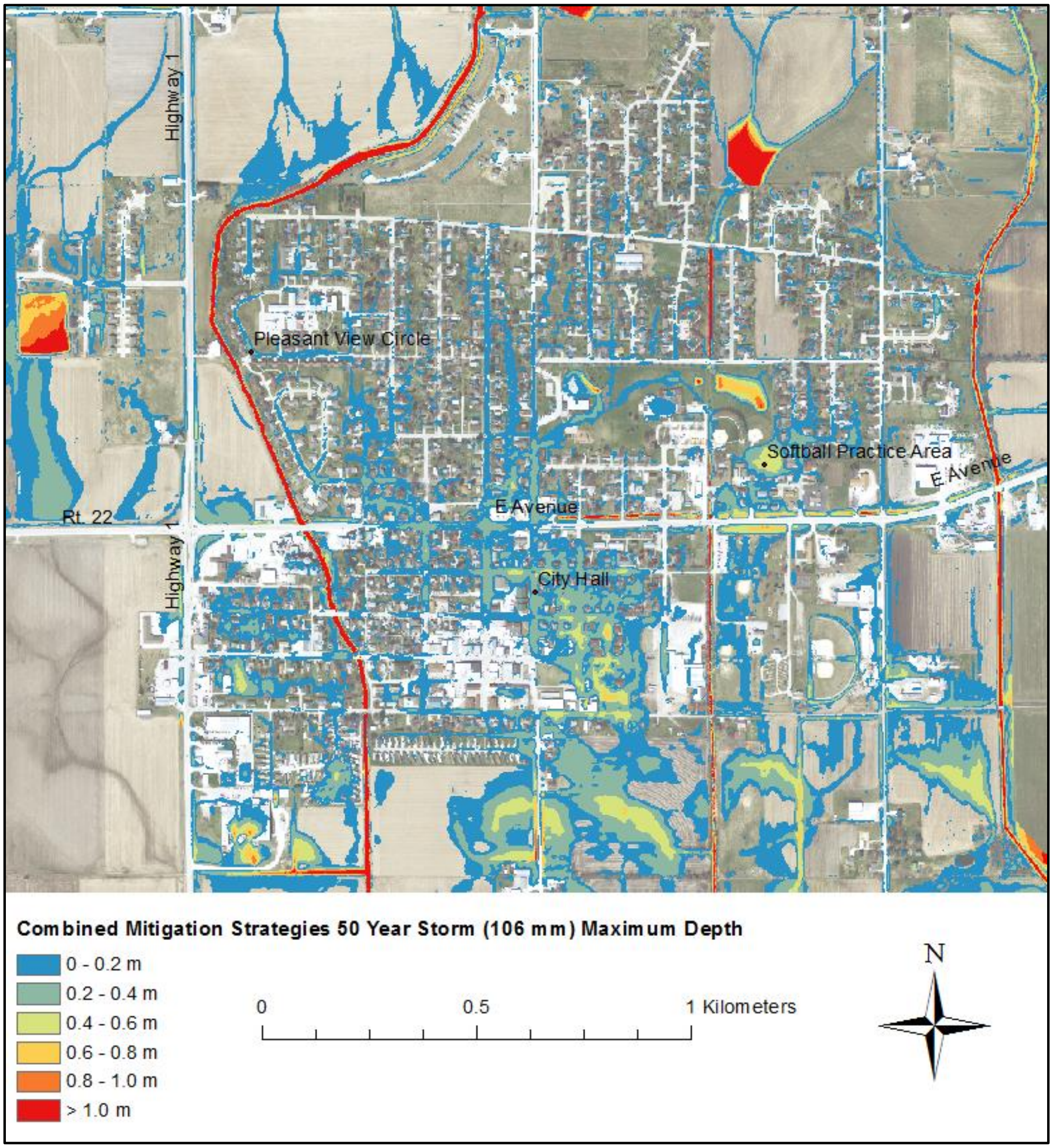

Figure E-2: Maximum Depth for a 50 Year (106 mm) Storm with Combined Flood Reduction Techniques

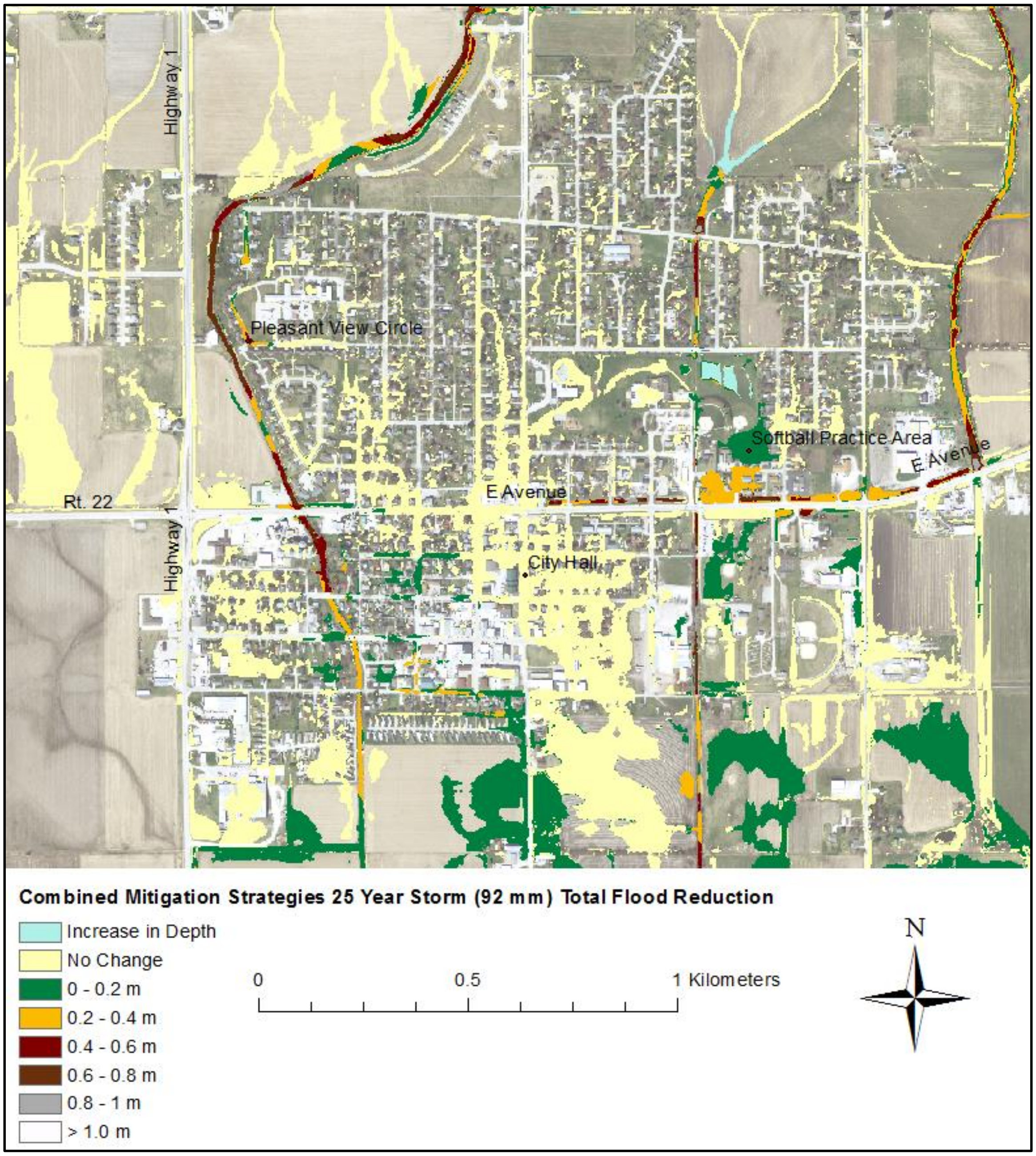

Figure E-3 : Total Flood Reduction for a 25 Year (92 mm) Storm with Combined Flood Reduction Techniques

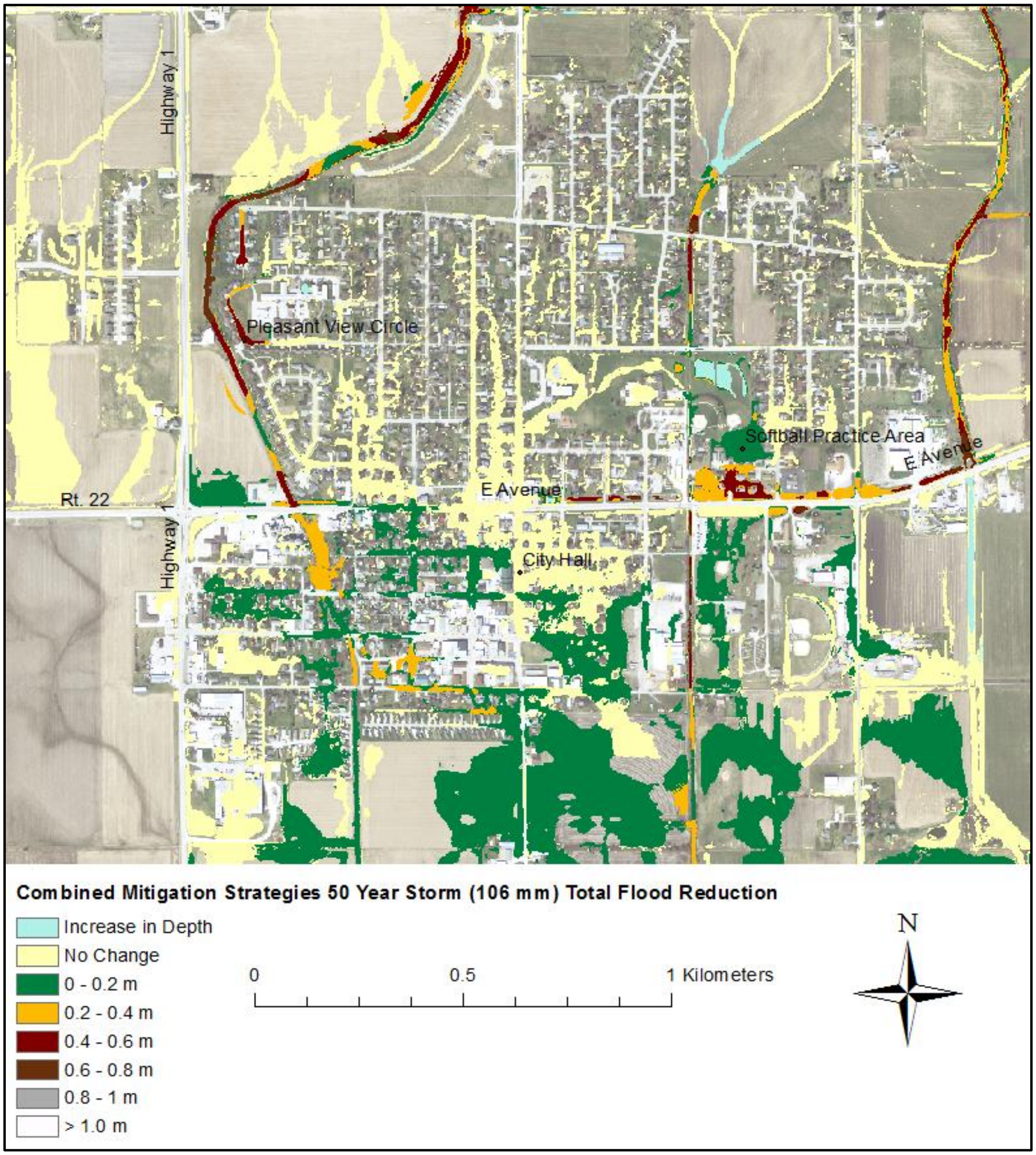

Figure E-4: Total Flood Reduction for a 50 Year (106 mm) Storm with Combined Flood Reduction Techniques

APPENDIX F. INDEX POINT DEPTH HYDROGRAPHS FOR THE 25 YEAR AND 50 YEAR STORMS

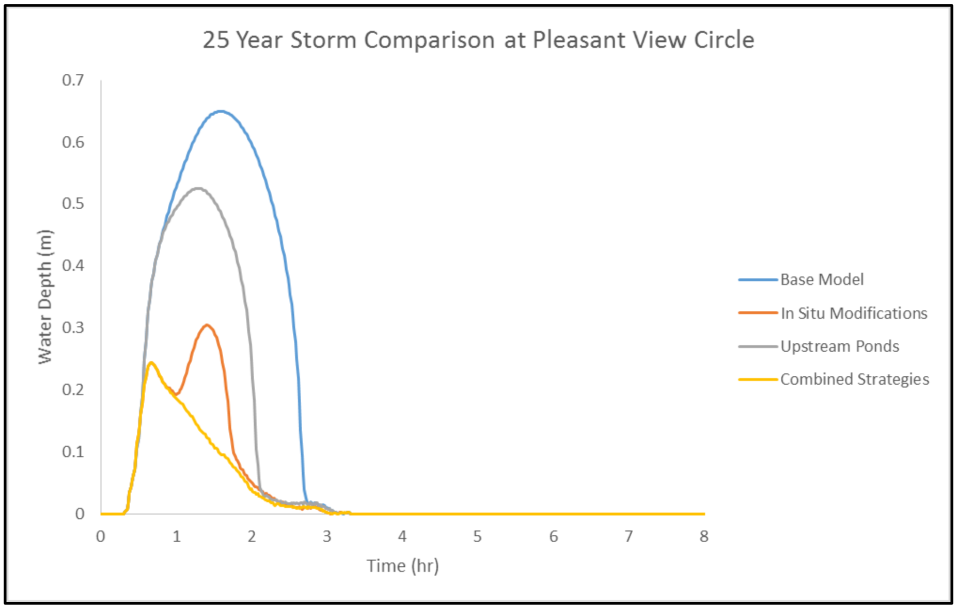

Figure F-1: Comparison of Flood Reduction Methods for the 25 Year (92 mm) Storm at Pleasant View Circle

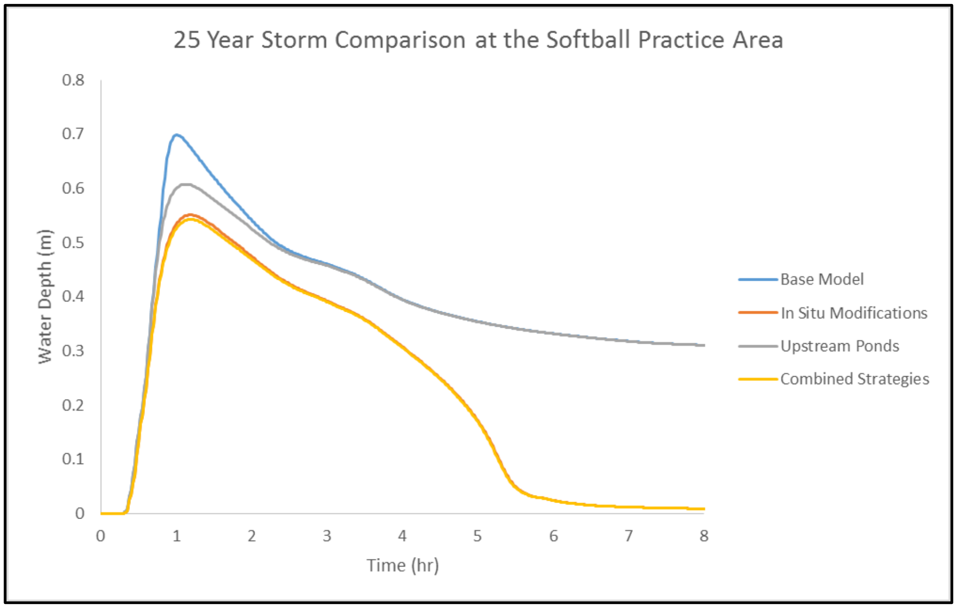

Figure F-2: Comparison of Flood Reduction Methods for the 25 Year (92 mm) Storm at the Softball Practice Area

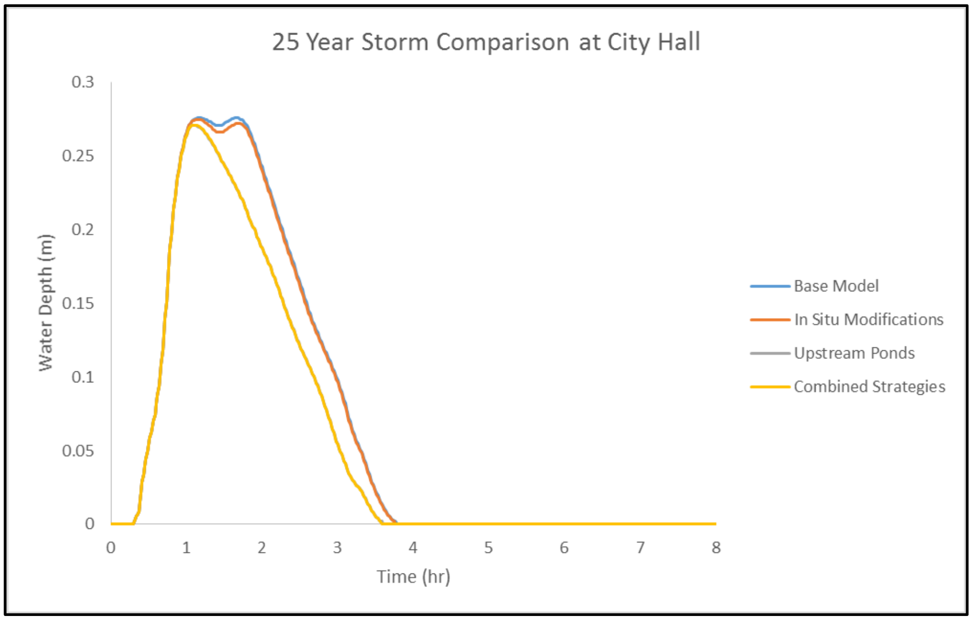

Figure F-3: Comparison of Flood Reduction Methods for the 25 Year (92 mm) Storm at City Hall

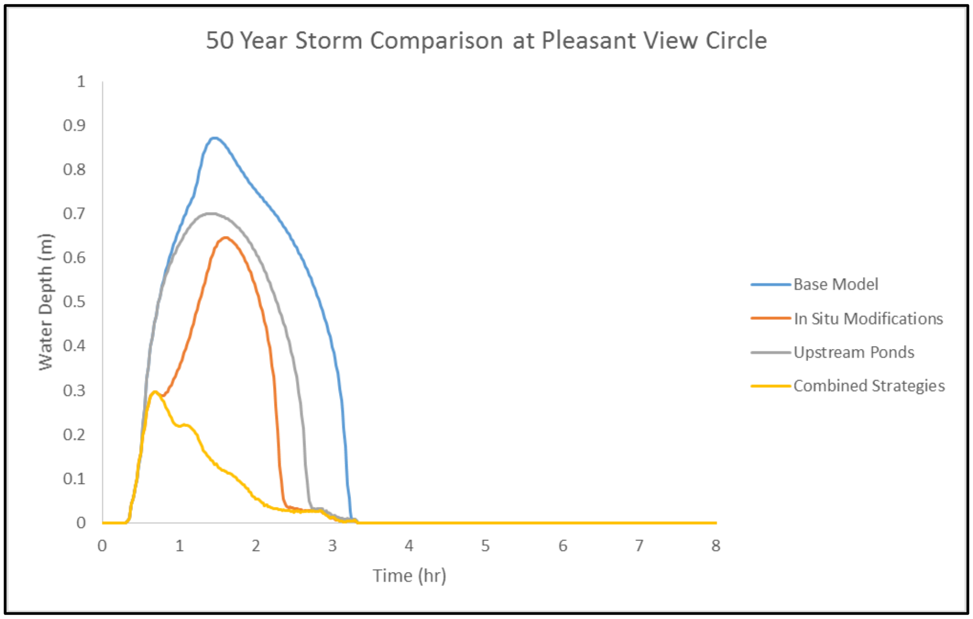

Figure F-4: Comparison of Flood Reduction Methods for the 50 Year (106 mm) Storm at Pleasant View Circle

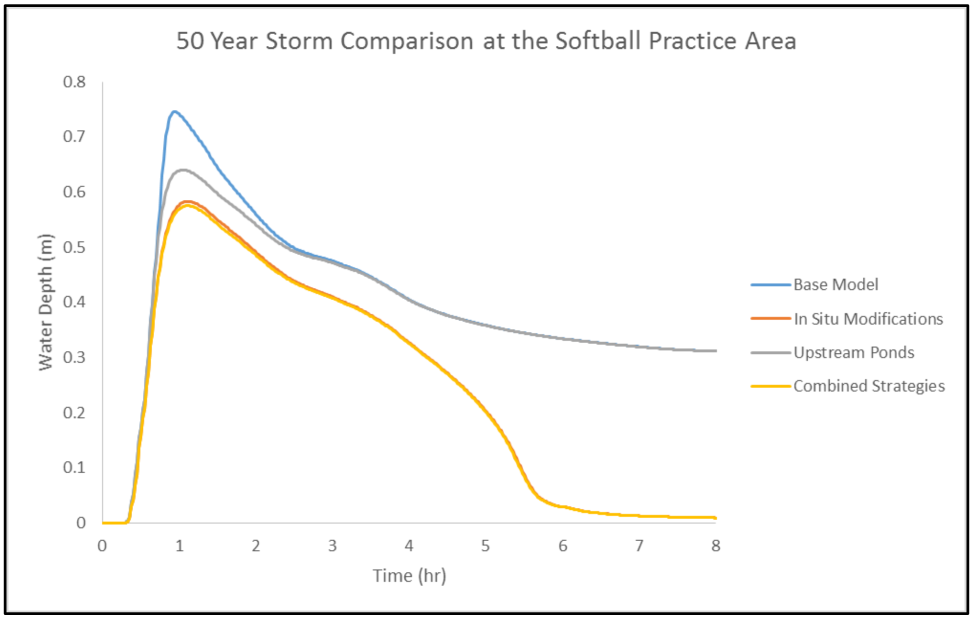

Figure F-5: Comparison of Flood Reduction Methods for the 50 Year (106 mm) Storm at the Softball Practice Area

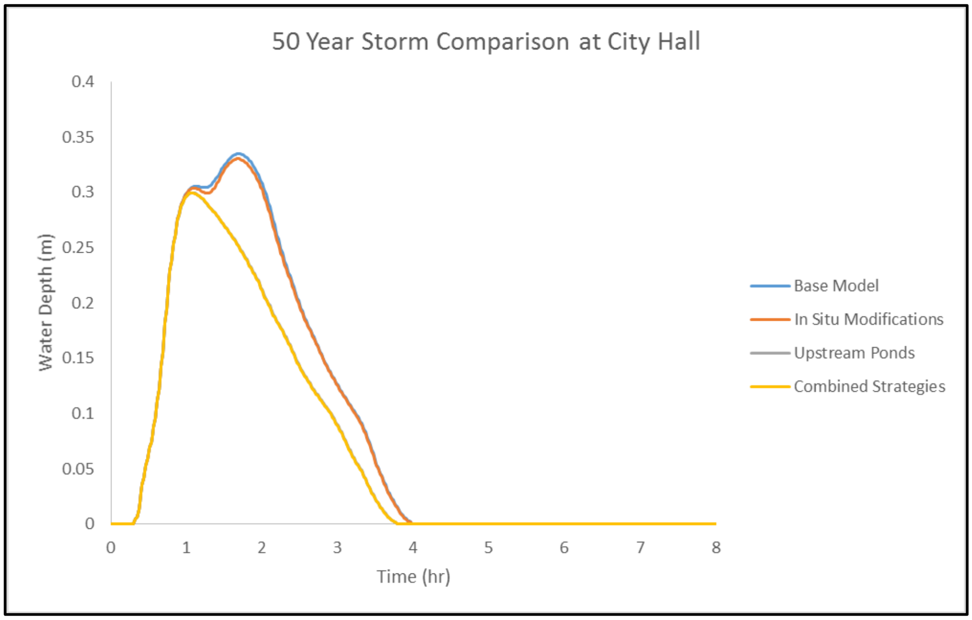

Figure F-6: Comparison of Flood Reduction Methods for the 50 Year (106 mm) Storm at City Hall

APPENDIX G. LOCATIONS FOR EACH CONDUIT AND NODE

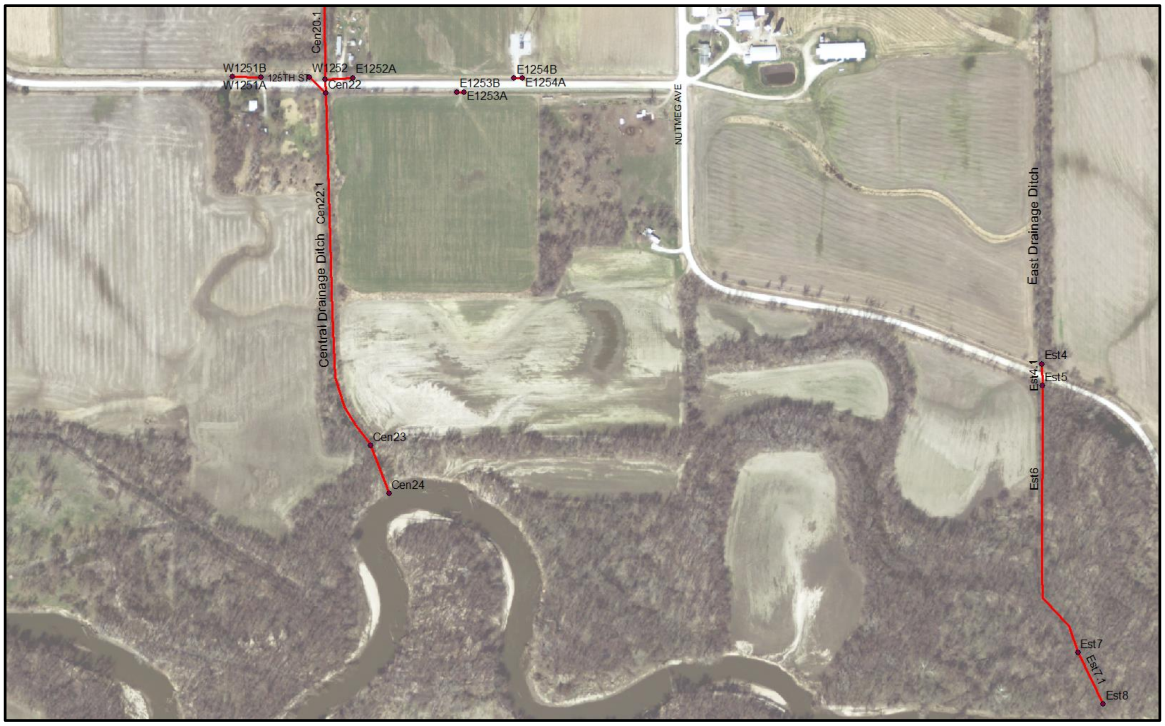

Figure G-1: Links and Nodes for the Downstream Ends of the Central Drainage Ditch and the East Drainage Ditch

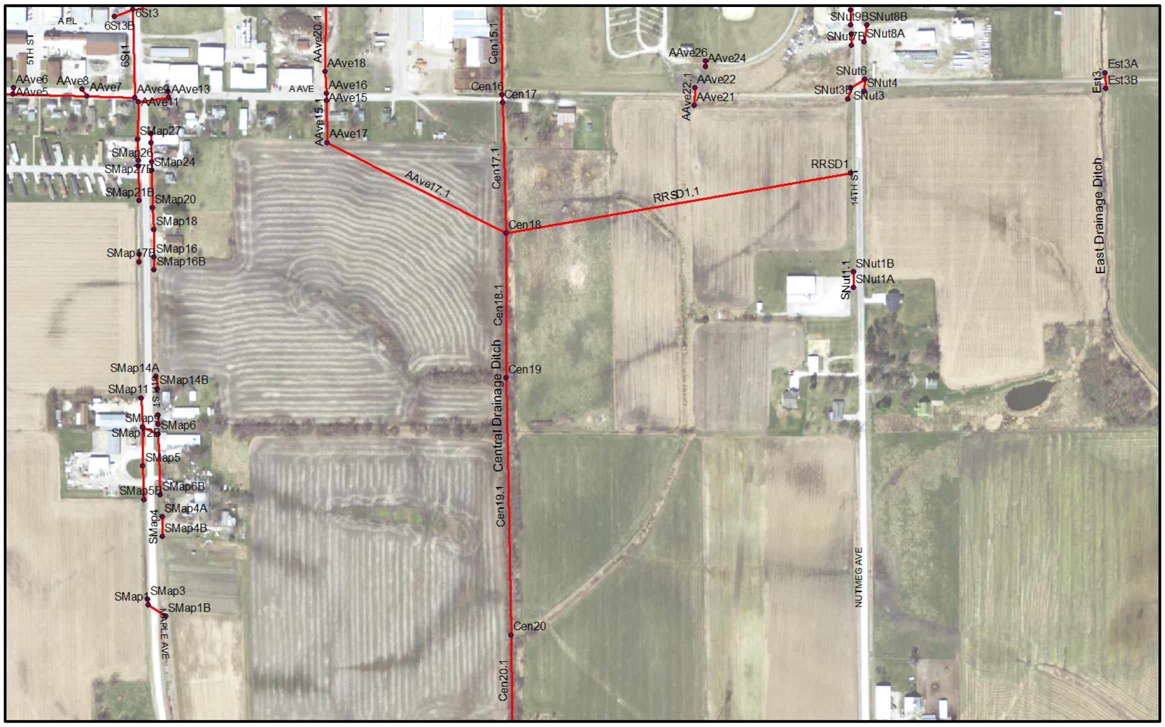

Figure G-2: Links and Nodes in Floodplain South of Kalona

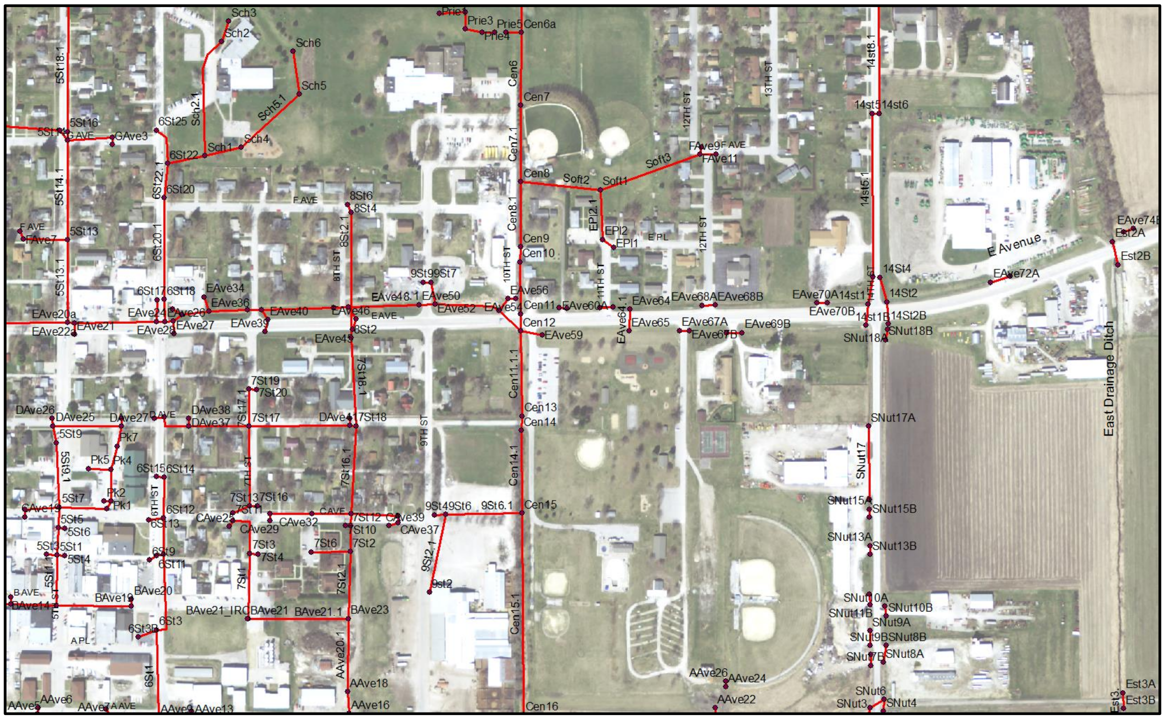

Figure G-3: Modeled Links and Nodes between 5th Street, the East Drainage Ditch A Avenue, and H Avenue

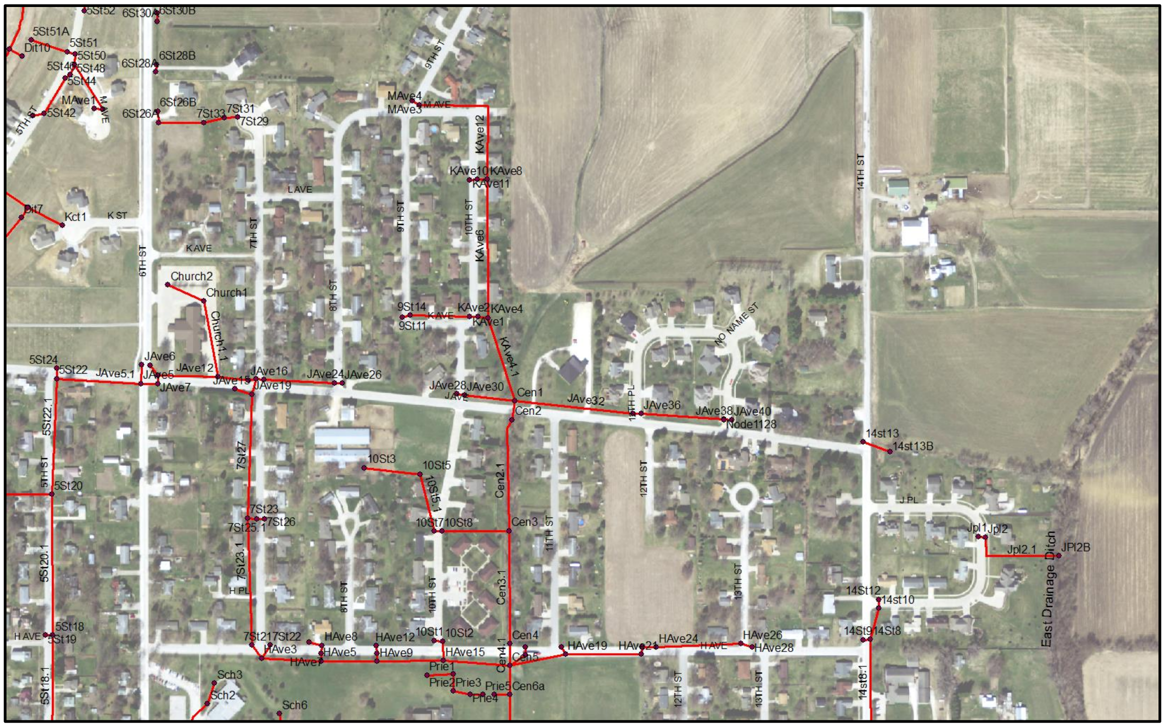

Figure G-4: Modeled Links and Nodes between 6th Street, 14th Street, H Avenue, and M Avenue

Figure G-5: Modeled Links and Nodes in Northern Agricultural Area

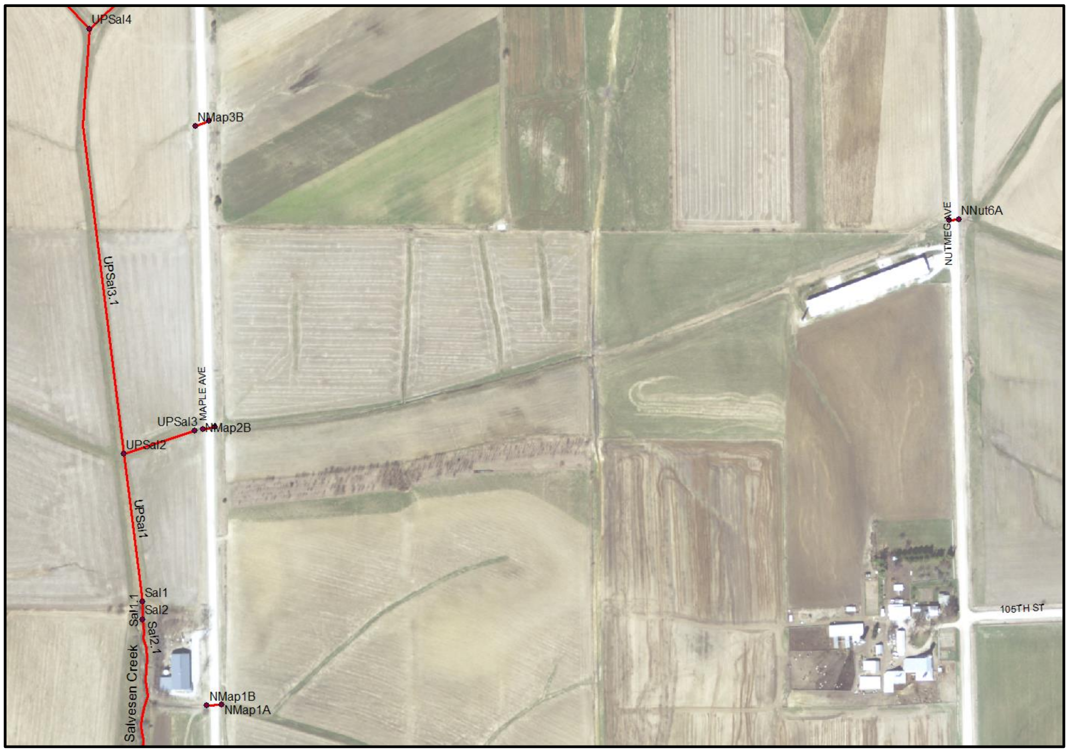

Figure G-6: Modeled Links and Nodes in Northern Agricultural Area

Figure G-7: Modeled Links and Nodes in Northern Agricultural Area

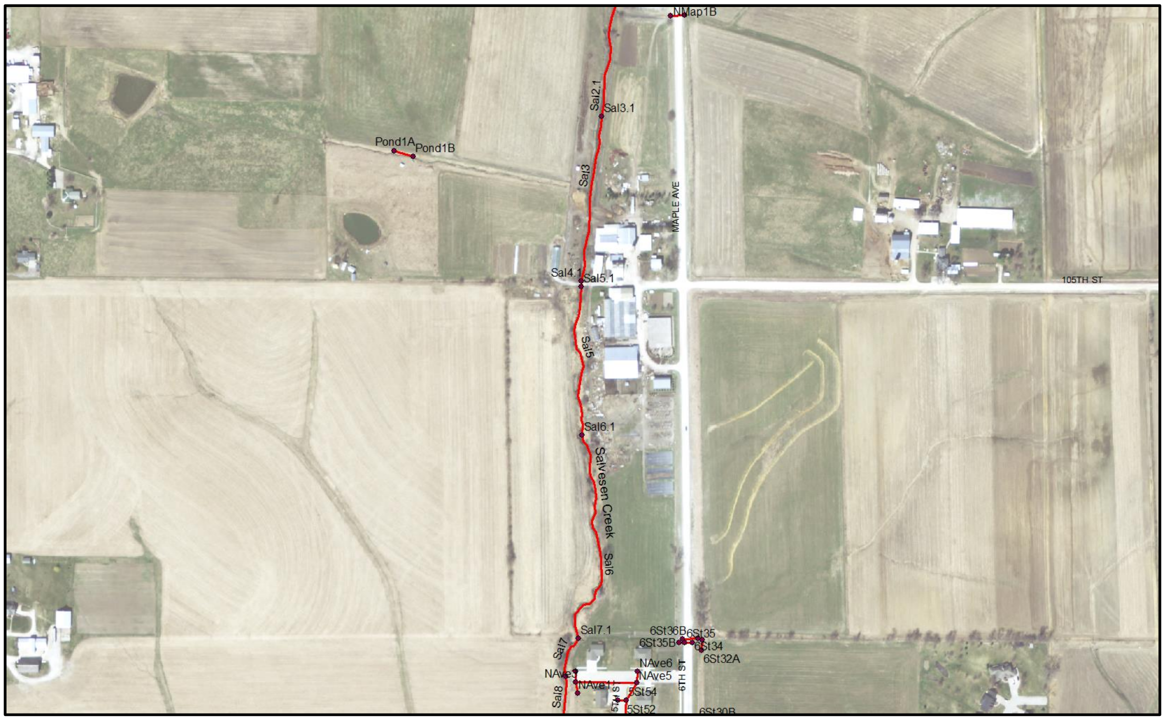

Figure G-8: Modeled Links and Nodes in Northern Agricultural Area

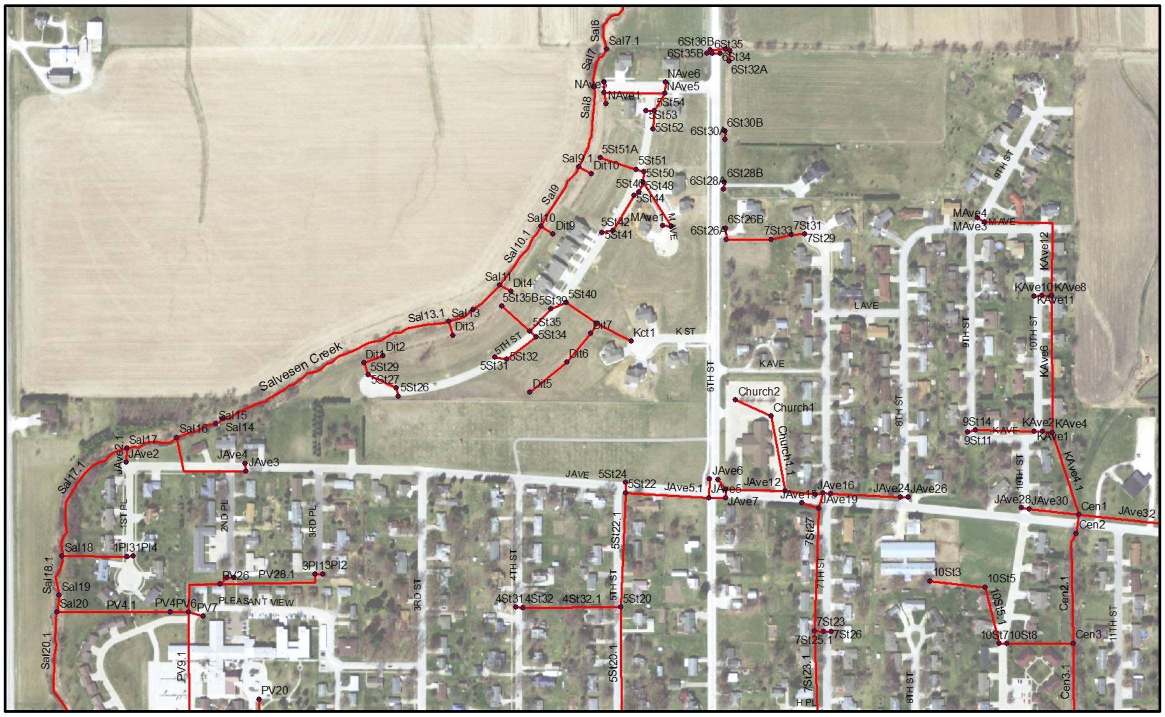

Figure G-9: Modeled Links and Nodes between Salvesen Creek, 10th Street, N Avenue, and J Avenue

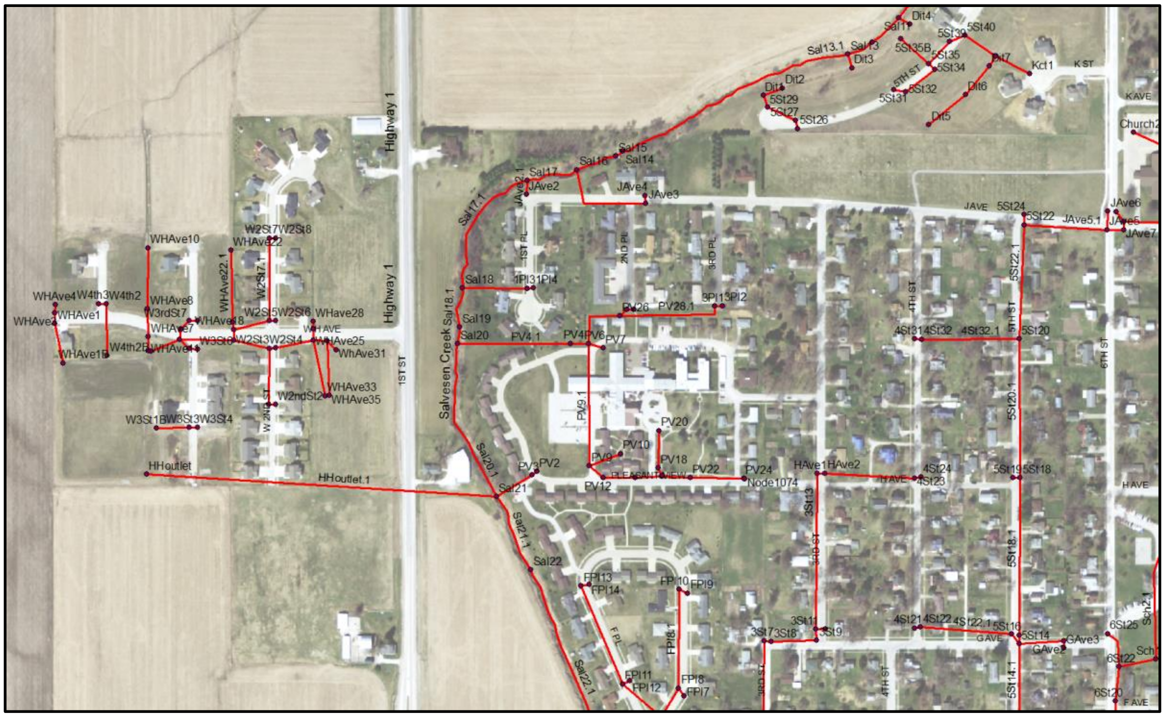

Figure G-10: Modeled Links and Nodes between W H Avenue, 6th Street, G Avenue, and J Avenue

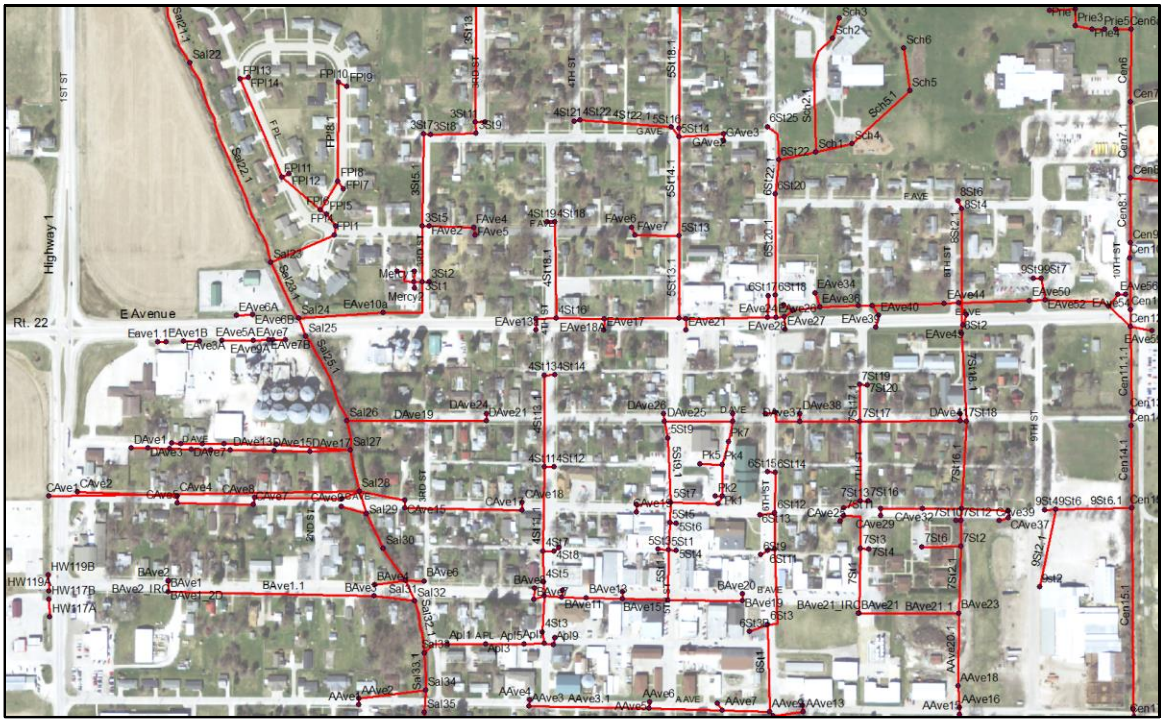

Figure G-11: Modeled Links and Nodes between Highway 1, the Central Drainage Ditch, A Avenue, and G Avenue

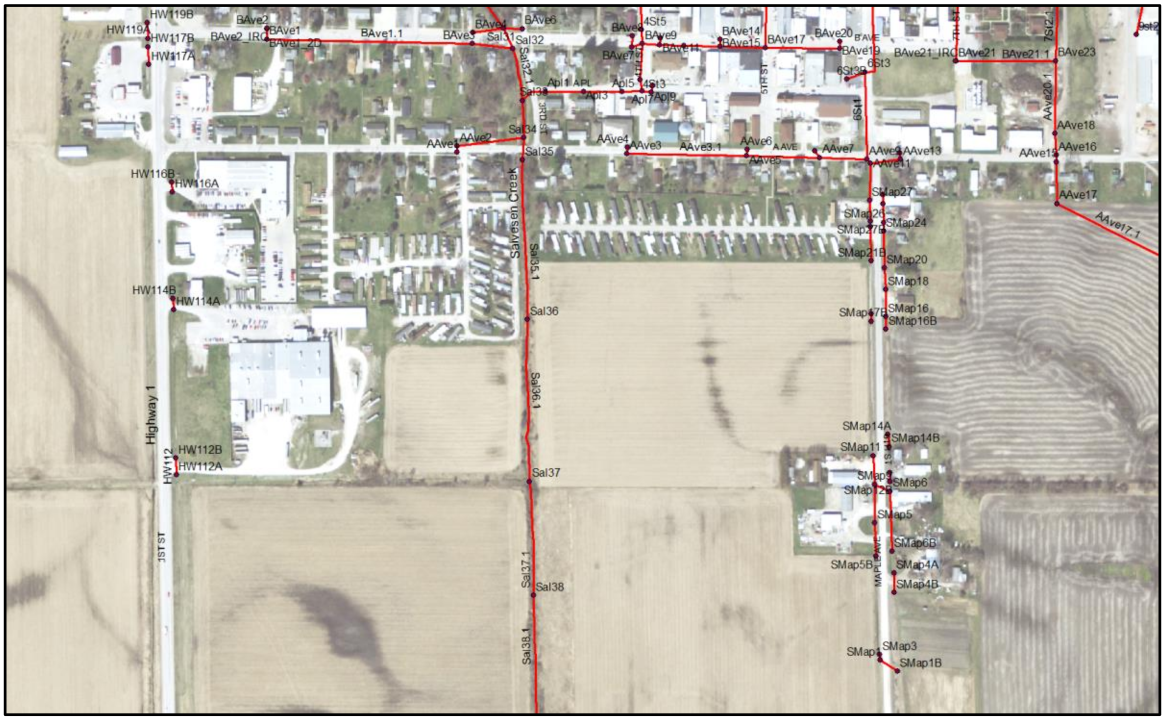

Figure G-12: Modeled Links and Nodes in the Southern Floodplain

Figure G-13: Modeled Links and Nodes in the Southern Floodplain

APPENDIX H. INPUT PARAMETERS FOR EACH LINK

Table H-1: Conduit Information for Links 1 – 30

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
1	10St1.1	10St1	10St2	9.14	0.305	Circular Pipe	0.012	ADS Plastic	0.80	0.0001	205.58	205.51	0	0
2	10St2.1	10St2	HAve15	21.34	0.356	Circular Pipe	0.012	ADS Plastic	3.21	0.0001	205.51	204.82	0	0
3	10St3.1	10St3	10St5	64.1	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.92	0.0001	209.66	208.43	0	0
4	10St5.1	10St5	10St7	66.01	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.03	0.0001	208.43	207.74	0	0
5	10St7.1	10St7	10St8	9.04	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.90	0.0001	207.74	207.66	0	0
6	10St8.1	10St8	Cen3	74.9	0.305	Circular Pipe	0.024	Corrugated Steel	0.10	0.0001	207.66	207.59	0	0
7	14st1.1	14st1	14st1B	24.35	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.09	0.0001	201.98	202	0.5	0
8	14st10.1	14st10	14St8	37.46	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	7.69	0.0001	211.77	208.89	0	0
9	14st12.1	14St12	14st10	9.18	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.65	0.0001	211.83	211.77	0	0
10	14st13.1	14st13	14st13B	31.73	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	4.64	0.0001	217.37	215.9	0	0
11	14St2.1	14St2	14St2B	24.88	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.86	0.0001	202.45	202.23	0.5	0
12	14st3.1	14st3	14st1	30.84	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.35	0.0001	202.29	202.4	0	0
13	14St4.1	14St4	14St2	28.59	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.32	0.0001	202.82	202.45	0	0
14	14st5.1	14st5	14st3	185.67	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	0.81	0.0001	203.8	202.29	0	0
15	14st7.1	14st6	14st5	8.21	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.35	0.0001	204.17	204.06	0	0
16	14st8.1	14St8	14st6	153.73	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	2.90	0.0001	208.89	204.42	0	0
17	14st9.1	14St9	14St8	8.13	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.38	0.0001	208.92	208.89	0	0
18	1Pl1	1Pl3	Sal18	73.68	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	203.78	203.04	0	0
19	1Pl4.1	1Pl4	1Pl3	7.25	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.17	0.0001	203.87	203.78	0	0
20	2Pl1.1	2Pl1	PV26	10.33	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	205.25	205.15	0	0
21	2Pl2.1	2Pl2	2Pl1	9.27	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	205.34	205.25	0	0
22	3Pl2.1	3Pl2	3Pl1	8.33	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	4.78	0.0001	209.02	208.62	0	0
23	3St12.1	3St12	3St11	10.94	0.203	Circular Pipe	0.012	ADS Plastic	2.31	0.0001	202.85	202.59	0	0
24	3St13	HAve1	3St11	176.68	0.305	Circular Pipe	0.012	ADS Plastic	1.84	0.0001	205.85	202.59	0	0
25	3St2.1	3St2	3St1	8.13	0.305	Circular Pipe	0.012	ADS Plastic	0.42	0.0001	201	200.97	0	0
26	3St3	3St5	3St1	63.27	0.508	Circular Pipe	0.012	ADS Plastic	0.17	0.0001	201.02	200.92	0	0
27	3St5.1	3St7	3St5	105.68	0.508	Circular Pipe	0.012	ADS Plastic	0.71	0.0001	201.77	201.02	0	0
28	3ST7.1	3St8	3St7	7.97	0.508	Circular Pipe	0.012	ADS Plastic	1.59	0.0001	201.9	201.77	0	0
29	3St8.1	3St9	3St8	51.58	0.508	Circular Pipe	0.012	ADS Plastic	0.00	0.0001	201.9	201.9	0	0
30	3St9.1	3St11	3St9	12.77	0.305	Circular Pipe	0.012	ADS Plastic	1.84	0.0001	202.59	202.36	0	0

Table H-2: Conduit Information for Links 31 – 60

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
31	4St1	4St3	Apl7	12.91	1.22	Circular Pipe	0.015	Reinforced Concrete Pipe	0.15	0.0001	198.54	198.52	0	0
32	4St10.1	4St10	4St8	7.5	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.36	0.0001	200.09	199.99	0	0
33	4St11.1	4St11	4St7	95.79	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.21	0.0001	200.07	199.88	0	0
34	4St12.1	4St12	4St11	11.85	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.17	0.0001	200.48	200.46	0	0
35	4St13.1	4St13	4St11	104.4	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.04	0.0001	200.19	200.15	0	0
36	4St14.1	4St14	4St13	11.86	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.77	0.0001	200.4	200.19	0	0
37	4St18.1	4St18	4St16	109.99	0.406	Circular Pipe	0.012	ADS Plastic	0.82	0.0001	201.34	200.45	0	0
38	4St19.1	4St19	4St18	9.13	0.254	Circular Pipe	0.012	ADS Plastic	3.63	0.0001	201.68	201.34	0	0
39	4St21.1	4St21	4St22	6.87	0.305	Circular Pipe	0.012	ADS Plastic	1.12	0.0001	203.84	203.76	0	0
40	4St22.1	4St22	5St15	103.96	0.305	Circular Pipe	0.012	ADS Plastic	1.70	0.0001	203.76	201.99	0	0
41	4St24.1	4St24	4St23	7.44	0.254	Circular Pipe	0.012	ADS Plastic	5.47	0.0001	207.36	206.96	0	0
42	4St3.1	BAve9	4St3	41.11	1.22	Circular Pipe	0.015	Reinforced Concrete Pipe	0.12	0.0001	198.59	198.54	0	0
43	4St31.1	4St31	4St32	7.26	0.203	Circular Pipe	0.012	ADS Plastic	0.66	0.0001	210.59	210.54	0	0
44	4St32.1	4St32	5St20	111.2	0.203	Circular Pipe	0.012	ADS Plastic	1.31	0.0001	210.54	209.09	0	0
45	4St5.1	4St5	BAve9	15.96	0.607	Circular Pipe	0.015	Reinforced Concrete Pipe	1.08	0.0001	199.27	199.1	0	0
46	4St7.1	4St7	4St5	35.04	0.607	Circular Pipe	0.015	Reinforced Concrete Pipe	1.73	0.0001	199.88	199.27	0	0
47	4St8.1	4St8	4St7	12.45	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.47	0.0001	200	199.94	0	0
48	5Pl4	FPl5	FPl4	16.76	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.95	0.0001	200.69	200.53	0	0
49	5St1.1	5St1	BAve17	56.78	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	0.12	0.0001	198.82	198.75	0	0
50	5St11	DAve25	5St9	18.94	0.381	Circular Pipe	0.015	Reinforced Concrete Pipe	0.74	0.0001	199.53	199.39	0	0
51	5St13.1	5St13	EAve20a	94	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.57	0.0001	200.67	200.13	0	0
52	5St14.1	5St14	5St13	112.38	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.57	0.0001	201.31	200.67	0	0
53	5St15.1	5St15	5St14	14.52	0.305	Circular Pipe	0.012	ADS Plastic	4.71	0.0001	201.99	201.31	0	0
54	5St16.1	5St16	5St14	10.13	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.50	0.0001	201.36	201.31	0	0
55	5St18.1	5St18	5St16	178.81	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.00	0.0001	204.86	201.28	0	0
56	5St19.1	5St19	5St18	8.55	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.00	0.0001	206.31	206.31	0	0
57	5St20.1	5St20	5St18	158.33	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	2.53	0.0001	208.86	204.86	0	0
58	5St22.1	5St22	5St20	129.83	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	3.96	0.0001	214	208.86	0	0
59	5St24.1	5St24	5St22	11.64	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	2.67	0.0001	214.31	214	0	0
60	5St26.1	5St26	5St27	11.01	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.87	0.0001	209.57	209.36	0	0

Table H-3: Conduit Information for Links 61 – 90

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
61	5St27.1	5St27	5St29	36	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	4.69	0.0001	209.36	207.67	0	0
62	5St29.1	5St29	Dit1	13.79	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.99	0.0001	207.67	207.54	0	0
63	5St3.1	5St3	5St1	12.72	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.68	0.0001	200.12	200.03	0	0
64	5St31.1	5St31	5St32	13.76	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.39	0.0001	209.19	209	0	0
65	5St32.1	5St32	5St34	43.97	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.13	0.0001	209	208.5	0	0
66	5St34.1	5St34	5St35	11.5	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.50	0.0001	207.49	207.31	0	0
67	5St35.1	5St35	5St35B	42.77	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.50	0.0001	207.31	207.1	0	0
68	5St37	5St39	5St35	37.74	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.28	0.0001	207.42	207.31	0	0
69	5St39.1	5St40	5St39	18.54	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.50	0.0001	207.7	207.42	0	0
70	5St4.1	5St4	5St1	8.4	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.02	0.0001	199.84	199.75	0	0
71	5St41.1	5St41	5St42	12.66	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.97	0.0001	209.39	209.14	0	0
72	5St42.1	5St42	5St44	43.1	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.18	0.0001	209.14	208.63	0	0
73	5St44.1	5St44	5St46	10.34	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.26	0.0001	208.63	208.5	0	0
74	5St46.1	5St46	5St48	12.43	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.35	0.0001	208.5	208.46	0	0
75	5St48.1	5St48	5St50	11.35	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	3.69	0.0001	208.46	208.04	0	0
76	5St5.1	5St5	5St1	31.03	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	0.12	0.0001	198.86	198.82	0	0
77	5St50.1	5St50	5St51	10.81	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.02	0.0001	208.04	207.93	0	0
78	5St51.1	5St51	5St51A	42.67	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	207.93	207.5	0	0
79	5St52.1	5St52	5St54	20.6	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.20	0.0001	208.44	208.19	0	0
80	5St53.1	5St53	5St54	9.06	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	1.77	0.0001	208.35	208.19	0	0
81	5St54.1	5St54	NAve5	23.41	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	2.64	0.0001	208.19	207.57	0	0
82	5St6.1	5St6	5St5	8.04	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.01	0.0001	199.71	199.63	0	0
83	5St7.1	5St7	5St5	23.64	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	0.10	0.0001	198.89	198.86	0	0
84	5St9.1	5St9	5St7	73.06	0.381	Circular Pipe	0.015	Reinforced Concrete Pipe	0.42	0.0001	199.39	199.09	0	0
85	6St1	6St3	AAve9	99.42	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.20	0.0001	199.8	198.61	0	0
86	6St11.1	6St11	6St4	8.99	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.76	0.0001	199.43	199.5	0	0
87	6St12.1	6St12	6St4	41.04	0.508	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.06	0.0001	199.48	199.5	0	0
88	6St13.1	6St13	6St12	17.43	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	199.65	199.48	0	0
89	6St14.1	6St14	6St12	45.96	0.508	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.06	0.0001	199.45	199.48	0	0
90	6St15.1	6St15	6St14	9.06	0.152	Circular Pipe	0.009	PVC Pipe	1.38	0.0001	199.88	199.76	0	0

Table H-4: Conduit Information for Links 91 – 120

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
91	6St17.1	6St17	EAve24	24.62	0.508	Circular Pipe	0.015	Reinforced Concrete Pipe	0.52	0.0001	199.81	199.68	0	0
92	6St18.1	6St18	EAve26	24.78	0.508	Circular Pipe	0.015	Reinforced Concrete Pipe	2.55	0.0001	200.27	199.64	0	0
93	6St20.1	6St20	6St18	115.07	0.508	Circular Pipe	0.015	Reinforced Concrete Pipe	0.06	0.0001	200.34	200.27	0	0
94	6St22.1	6St22	6St20	39.22	0.508	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.37	0.0001	200.2	200.34	0	0
95	6St25.1	6St25	6St22	44.07	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	3.04	0.0001	201.54	200.2	0	0
96	6St26	6St26A	6St26B	12.76	0.61	Circular Pipe	0.024	Corrugated Steel	2.55	0.0001	217.31	216.98	0.5	0
97	6St28	6St28A	6St28B	8.24	0.61	Circular Pipe	0.013	Ceramic Tile	3.90	0.0001	215.81	215.49	0.9	0
98	6St3.1	6St3B	6St3	22.04	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.51	0.0001	200.13	199.8	0	0
99	6St30	6St30A	6St30B	9.38	0.61	Circular Pipe	0.013	Ceramic Tile	2.29	0.0001	213.77	213.55	0.9	0
100	6St32.1	6St32A	6St32B	12.57	0.508	Circular Pipe	0.024	Corrugated Steel	4.78	0.0001	211.1	210.5	0.9	0
101	6St34.1	6St34	6St35	8.95	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.34	0.0001	211.22	211.19	0	0
102	6St35.1	6St35	6St35B	6.22	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	11.33	0.0001	211.19	210.48	0	0
103	6St36.1	6St36A	6St36B	18	1.311	Box Pipe	0.015	Reinforced Concrete Pipe	2.10	1.2192	210.53	210.15	0.4	0
104	6St4.1	6St4	6St3	96.77	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.31	0.0001	199.5	199.8	0	0
105	6St9.1	6St9	6St11	10	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.42	0.0001	199.47	199.43	0	0
106	7St1	7St3	BAve21	74.31	0.305	Circular Pipe	0.012	ADS Plastic	0.15	0.0001	199.4	199.3	0	0
107	7St10.1	7St10	7St12	6.09	0.305	Circular Pipe	0.012	ADS Plastic	17.28	0.0001	198.87	197.81	0	0
108	7St11.1	7St11	7St13	20.69	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.65	0.0001	199.58	199.45	0	0
109	7St12.1	CAve34	7St12	13.8	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.09	0.0001	197.8	197.81	0	0
110	7St14	7St16	7St13	8.61	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.77	0.0001	199.6	199.45	0	0
111	7St15	7St13	7St17	89.82	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.45	0.0001	199.45	199.04	0	0
112	7St16.1	7St18	CAve34	99.62	0.61	Circular Pipe	0.012	ADS Plastic	0.37	0.0001	198.17	197.8	0	0
113	7St17.1	7St19	7St17	42.46	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.74	0.0001	199.35	199.04	0	0
114	7St18.1	8St2	7St18	99.68	0.61	Circular Pipe	0.012	ADS Plastic	0.37	0.0001	198.54	198.17	0	0
115	7St2.1	7St2	BAve23	75.69	0.813	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.09	0.0001	197.84	197.91	0	0
116	7St20.1	7St20	7St19	9.13	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.47	0.0001	199.4	199.35	0	0
117	7St21.1	7St21	HAve3	18.55	0.305	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	205.91	205.72	0	0
118	7St22.1	7St22	HAve3	17.86	0.203	Circular Pipe	0.012	ADS Plastic	0.23	0.0001	205.76	205.72	0	0
119	7St23.1	7St23	7St21	142.43	0.305	Circular Pipe	0.012	ADS Plastic	2.86	0.0001	209.99	205.91	0	0
120	7St25	7St25.1	7St23	10.09	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	210.09	209.99	0	0

Table H-5: Conduit Information for Links 121 – 150

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
121	7St26.1	7St26	7St25.1	9.06	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	3.87	0.0001	210.44	210.09	0	0
122	7St27	JAve19	7St23	138.91	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	3.08	0.0001	214.62	210.34	0	0
123	7St29.1	7St29	7St31	16.01	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	6.00	0.0001	222.21	221.25	0	0
124	7St31.1	7St31	7St33	22.93	0.305	Circular Pipe	0.012	ADS Plastic	5.19	0.0001	218.86	217.67	0	0
125	7St33.1	7St33	6St26A	51.46	0.305	Circular Pipe	0.012	ADS Plastic	0.06	0.0001	217.67	217.64	0	0
126	7St4.1	7St4	7St3	9.32	0.254	Circular Pipe	0.012	ADS Plastic	-0.48	0.0001	199.49	199.53	0	0
127	7St6.1	7St6	7St2	44.9	0.254	Circular Pipe	0.012	ADS Plastic	1.06	0.0001	198.32	197.84	0	0
128	7St7	CAve27	7St3	55.52	0.254	Circular Pipe	0.012	ADS Plastic	0.09	0.0001	199.46	199.4	0	0
129	7St8.1	7St12	7St2	29.39	0.813	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.09	0.0001	197.81	197.84	0	0
130	8St2.1	8St4	8St2	142.29	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	2.05	0.0001	201.46	198.54	0	0
131	8St4.1	8St6	8St4	10.05	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.60	0.0001	201.4	201.46	0	0
132	9St11.1	9St11	9St14	9.31	0.356	Circular Pipe	0.012	ADS Plastic	3.15	0.0001	220.48	220.18	0	0
133	9St14.1	9St14	KAve1	67.15	0.356	Circular Pipe	0.012	ADS Plastic	6.84	0.0001	220.18	215.59	0	0
134	9St2.1	9st2	9St6	89.43	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.25	0.0001	199.14	198.91	0	0
135	9St4.1	9St4	9St6	12.93	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	4.69	0.0001	199.52	198.91	0.5	0
136	9St6.1	9St6	Cen15	86.62	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.50	0.0001	198.91	198.48	0	0
137	9St7.1	9St7	EAve52	25.46	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	0.39	0.0001	200.61	200.51	0	0
138	9St8	9St9	9St7	9.03	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	1.65	0.0001	200.76	200.61	0	0
139	AAve1.1	AAve1	AAve2	8.19	0.254	Circular Pipe	0.012	ADS Plastic	-0.24	0.0001	200.34	200.36	0	0
140	AAve10.1	AAve10	AAve13	8.29	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.54	0.0001	198.92	198.87	0	0
141	AAve11.1	AAve13	AAve11	34.24	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.11	0.0001	198.87	198.49	0	0
142	AAve15.1	AAve15	AAve17	47.17	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	197.34	196.87	0	0
143	AAve16.1	AAve16	AAve15	8.17	0.813	Circular Pipe	0.015	Reinforced Concrete Pipe	-1.88	0.0001	197.19	197.34	0	0
144	AAve17.1	AAve17	Cen18	226.37	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.31	0.0001	196.87	197.57	0	0
145	AAve18.1	AAve18	AAve16	24.17	0.813	Circular Pipe	0.012	ADS Plastic	3.33	0.0001	197.99	197.19	0	0
146	AAve2.1	AAve2	Sal34	76.99	0.305	Circular Pipe	0.012	ADS Plastic	1.76	0.0001	200.36	199	0	0
147	AAve20.1	BAve23	AAve18	83.01	0.813	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.09	0.0001	197.91	197.99	0	0
148	AAve22.1	AAve22	AAve21	19.4	0.305	Circular Pipe	0.012	ADS Plastic	1.72	0.0001	199.46	199.12	0.9	0
149	AAve26.1	AAve26	AAve24	6.19	0.61	Circular Pipe	0.024	Corrugated Steel	1.03	0.0001	199.67	199.6	0.9	0
150	AAve3.1	AAve3	AAve5	137.09	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.35	0.0001	199.71	199.23	0	0

Table H-6: Conduit Information for Links 151 – 180

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
151	AAve4.1	AAve4	AAve3	8.18	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.50	0.0001	199.75	199.71	0	0
152	AAve5.1	AAve5	AAve7	83.17	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.47	0.0001	199.23	198.84	0	0
153	AAve6.1	AAve6	AAve5	8.21	0.152	Circular Pipe	0.009	PVC Pipe	-0.35	0.0001	199.2	199.23	0	0
154	AAve7.1	AAve7	AAve9	50.61	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.46	0.0001	198.84	198.61	0	0
155	AAve8.1	AAve8	AAve7	10.09	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	2.43	0.0001	199.08	198.84	0	0
156	AAve9.1	AAve9	AAve11	8.59	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.35	0.0001	198.61	198.49	0	0
157	Apl1.1	Apl1	Sal33	30.57	1.22	Circular Pipe	0.015	Reinforced Concrete Pipe	0.53	0.0001	198.39	198.23	0	0
158	Apl10.1	Apl10	Apl9	8.35	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.41	0.0001	199.75	199.72	0	0
159	Apl3.1	Apl3	Apl1	43.69	1.22	Circular Pipe	0.015	Reinforced Concrete Pipe	0.12	0.0001	198.44	198.39	0	0
160	Apl5.1	Apl5	Apl3	44.13	1.22	Circular Pipe	0.015	Reinforced Concrete Pipe	0.00	0.0001	198.44	198.44	0	0
161	Apl7.1	Apl7	Apl5	22.66	1.22	Circular Pipe	0.015	Reinforced Concrete Pipe	0.11	0.0001	198.52	198.5	0	0
162	Apl9.1	Apl9	Apl7	10.44	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.14	0.0001	199.66	199.54	0	0
163	BAve1.1	BAve1	BAve3	234.63	0.305	Circular Pipe	0.012	ADS Plastic	0.24	0.0001	200.48	199.93	0	0
164	BAve10.1	BAve10	BAve11	8.4	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.95	0.0001	199.88	199.8	0	0
165	BAve11.1	BAve13	BAve11	27.95	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.12	0.0001	198.64	198.61	0	0
166	BAve13.1	BAve15	BAve13	40.3	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.12	0.0001	198.69	198.64	0	0
167	BAve14.1	BAve14	BAve15	8.17	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	200.22	200.14	0	0
168	BAve15.1	BAve17	BAve15	51.97	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.12	0.0001	198.75	198.69	0	0
169	BAve17.1	BAve19	BAve17	85.36	0.381	Circular Pipe	0.015	Reinforced Concrete Pipe	0.40	0.0001	199.41	199.07	0	0
170	BAve2.1	BAve2	BAve1	13.31	0.305	Circular Pipe	0.012	ADS Plastic	0.08	0.0001	200.42	200.41	0	0
171	BAve20.1	BAve20	BAve19	8.19	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.37	0.0001	199.47	199.44	0	0
172	BAve21.1	BAve21	BAve23	114.1	0.406	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	199.05	197.91	0	0
173	BAve3.1	BAve3	Sal32	48.13	0.305	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	199.93	199.45	0	0
174	BAve4.1	BAve4	Sal31	34.85	0.305	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	200.01	199.66	0	0
175	BAve6.1	BAve6	Sal31	22.55	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	200.01	199.79	0	0
176	BAve7.1	BAve7	BAve9	12.92	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.85	0.0001	199.81	199.7	0	0
177	BAve8.1	BAve8	BAve7	13.37	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.40	0.0001	199.92	199.87	0	0
178	BAve9.1	BAve11	BAve9	19.71	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.13	0.0001	198.61	198.59	0	0
179	CAve1.1	CAve1	Sal28	352.53	0.203	Circular Pipe	0.013	Ceramic Tile	0.50	0.0001	201.2	199.44	0	0
180	CAve10.1	CAve10	Sal28	21.4	0.203	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	201.26	201.04	0	0

Table H-7: Conduit Information for Links 181 – 210

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
181	CAve12	CAve14	Sal28	54.29	0.356	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	200.59	200.04	0	0
182	CAve14.1	CAve15	CAve14	9.68	0.356	Circular Pipe	0.012	ADS Plastic	5.02	0.0001	201.07	200.59	0	0
183	CAve15.1	CAve17	CAve15	133.29	0.305	Circular Pipe	0.012	ADS Plastic	-0.26	0.0001	200.73	201.07	0	0
184	CAve17.1	CAve18	CAve17	9.69	0.305	Circular Pipe	0.012	ADS Plastic	1.78	0.0001	200.75	200.58	0	0
185	CAve19.1	CAve19	CAve20	9.36	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.05	0.0001	199.89	199.79	0	0
186	CAve2.1	CAve2	CAve4	114.17	0.457	Circular Pipe	0.013	Ceramic Tile	1.00	0.0001	201.93	200.79	0	0
187	CAve20.1	CAve20	5St7	38.64	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.91	0.0001	199.73	199.38	0	0
188	CAve22	CAve24	5St7	54.17	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.86	0.0001	199.35	198.89	0	0
189	CAve24.1	Pk1	CAve24	10.23	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.19	0.0001	199.37	199.35	0	0
190	CAve25.1	CAve25	CAve27	8.25	0.254	Circular Pipe	0.012	ADS Plastic	1.67	0.0001	199.59	199.46	0	0
191	CAve29.1	CAve29	CAve30	9.16	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.05	0.0001	199.08	199.09	0	0
192	CAve30.1	CAve30	CAve32	47.17	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.59	0.0001	199.09	198.34	0	0
193	CAve32.1	CAve32	CAve34	44.87	0.305	Circular Pipe	0.012	ADS Plastic	1.19	0.0001	198.34	197.8	0	0
194	CAve34.1	CAve36	CAve34	53.07	0.305	Circular Pipe	0.012	ADS Plastic	1.70	0.0001	198.71	197.8	0	0
195	CAve36.1	CAve37	CAve36	9.14	0.305	Circular Pipe	0.012	ADS Plastic	0.82	0.0001	198.78	198.71	0	0
196	CAve37.1	CAve39	CAve37	11.15	0.305	Circular Pipe	0.012	ADS Plastic	1.85	0.0001	198.99	198.78	0	0
197	CAve4.1	CAve4	CAve5	9.09	0.254	Circular Pipe	0.012	ADS Plastic	-0.25	0.0001	200.96	200.98	0	0
198	CAve5.1	CAve5	CAve7	86.82	0.305	Circular Pipe	0.012	ADS Plastic	-0.38	0.0001	201.02	201.35	0	0
199	CAve7.1	CAve7	CAve8	8.97	0.254	Circular Pipe	0.012	ADS Plastic	0.96	0.0001	201.4	201.32	0	0
200	CAve8.1	CAve8	CAve10	99.52	0.305	Circular Pipe	0.012	ADS Plastic	0.08	0.0001	201.34	201.26	0	0
201	CAve9.1	CAve9	Sal29	32.76	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	201.18	200.85	0	0
202	Cen1.1	Cen1	Cen2	21.32	1.219	Circular Pipe	0.024	Corrugated Steel	0.82	0.0001	210.04	209.86	1.2	0.3
203	Cen10.1	Cen10	Cen11	58.72	0	Natural Section	0.04	Natural Section	1.51	0.0001	200.44	199.55	0	0
204	Cen11.1	Cen11	Cen12	19.31	1.219	Box Pipe	0.015	Reinforced Concrete Pipe	8.69	2.4384	199.55	197.87	0.7	0.3
205	Cen11.1.1	Cen12	Cen13	96.51	0	Natural Section	0.04	Natural Section	-0.53	0.0001	197.87	198.38	0	0
206	Cen13.1	Cen13	Cen14	16.3	2.134	Non-Circular Pipe	0.012	ADS Plastic	0.52	0.0001	198.38	198.3	1.2	0.3
207	Cen14.1	Cen14	Cen15	93.83	0	Natural Section	0.04	Natural Section	0.21	0.0001	198.3	198.1	0	0
208	Cen15.1	Cen15	Cen16	228.37	0	Natural Section	0.04	Natural Section	0.21	0.0001	198.1	197.61	0	0
209	Cen16.1	Cen16	Cen17	9.04	2.134	Circular Pipe	0.024	Corrugated Steel	0.97	0.0001	197.61	197.52	1.2	0.3
210	Cen17.1	Cen17	Cen18	146.63	0.05	Natural Section	0.04	Natural Section	0.19	0.0001	197.52	197.24	0	0

Table H-8: Conduit Information for Links 211 – 240

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
211	Cen18.1	Cen18	Cen19	162.59	0.05	Natural Section	0.04	Natural Section	0.19	0.0001	197.24	196.93	0	0
212	Cen19.1	Cen19	Cen20	289.58	0	Natural Section	0.04	Natural Section	0.19	0.0001	196.93	196.37	0	0
213	Cen2.1	Cen2	Cen3	126.19	0	Natural Section	0.04	Natural Section	1.66	0.0001	209.41	207.32	0	0
214	Cen20.1	Cen20	Cen21	165.07	0.05	Natural Section	0.04	Natural Section	0.19	0.0001	196.37	196.05	0	0
215	Cen21.1	Cen21	Cen22	15.49	1.737	Non-Circular Pipe	0.012	ADS Plastic	1.35	0.0001	196.05	195.84	1.2	0.3
216	Cen22.1	Cen22	Cen23	422.1	0	Natural Section	0.04	Natural Section	0.10	0.0001	195.84	195.42	0	0
217	Cen23.1	Cen23	Cen24	38.48	0.05	Natural Section	0.04	Natural Section	0.10	0.0001	195.42	195.38	0	0
218	Cen3.1	Cen3	Cen4	126.53	0	Natural Section	0.04	Natural Section	1.65	0.0001	207.32	205.23	0	0
219	Cen4.1	Cen4	Cen5	24.71	1.219	Circular Pipe	0.015	Reinforced Concrete Pipe	3.43	0.0001	205.23	204.38	0.7	0.3
220	Cen5.1	Cen5	Cen6a	32.45	1.575	Circular Pipe	0.024	Corrugated Steel	2.06	0.0001	204.38	203.71	0	0
221	Cen6	Cen6a	Cen7	82.77	1.575	Circular Pipe	0.024	Corrugated Steel	1.97	0.0001	203.71	202.08	0	0
222	Cen7.1	Cen7	Cen8	86.46	1.219	Non-Circular Pipe	0.024	Corrugated Steel	0.61	0.0001	202.08	201.55	0	0.3
223	Cen8.1	Cen8	Cen9	73.81	0	Natural Section	0.04	Natural Section	0.84	0.0001	201.55	200.93	0	0
224	Cen9.1	Cen9	Cen10	16.9	1.346	Circular Pipe	0.024	Corrugated Steel	2.95	0.0001	200.93	200.44	1.2	0.3
225	Church1.1	Church1	JAve14	86.67	0.305	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	216.59	215.72	0	0
226	Church2.1	Church2	Church1	45.61	0.305	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	217.05	216.59	0	0
227	DAve1.1	DAve1	DAve3	18.97	0.254	Circular Pipe	0.012	ADS Plastic	0.26	0.0001	201.67	201.62	0	0
228	DAve10.1	DAve10	DAve12	24.22	0.305	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	201.14	200.9	0	0
229	DAve11.1	DAve11	DAve13	22.79	0.254	Circular Pipe	0.012	ADS Plastic	2.67	0.0001	201.51	200.9	0	0
230	DAve12.1	DAve12	DAve16	59.91	0.305	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	200.9	200.3	0	0
231	DAve13.1	DAve13	DAve15	49.44	0.254	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	200.9	200.41	0	0
232	DAve15.1	DAve15	DAve17	40.66	0.254	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	200.41	200	0	0
233	DAve16.1	DAve16	Sal27	84.58	0.305	Circular Pipe	0.012	ADS Plastic	0.50	0.0001	200.3	199.88	0	0
234	DAve17.1	DAve17	Sal27	46.64	0.254	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	200	199.53	0	0
235	DAve19	DAve21	Sal26	158.27	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	200.59	199.01	0	0
236	DAve24.1	DAve24	DAve21	9.08	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.12	0.0001	200.76	200.77	0	0
237	DAve25.1	DAve27	DAve25	78.03	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.00	0.0001	199.54	199.53	0	0
238	DAve26.1	DAve26	DAve25	9.11	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.87	0.0001	199.74	199.57	0	0
239	DAve28.1	DAve28	DAve27	9.09	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.24	0.0001	199.56	199.54	0	0
240	DAve3.1	DAve3	DAve5	24.42	0.254	Circular Pipe	0.012	ADS Plastic	-0.07	0.0001	201.62	201.64	0	0

Table H-9: Conduit Information for Links 241 – 270

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
241	DAve32.1	DAve32	DAve34	11.5	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.67	0.0001	199.74	199.67	0	0
242	DAve35	DAve34	DAve37	38.45	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.56	0.0001	199.59	198.99	0	0
243	DAve37.1	DAve37	7St17	68.31	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.07	0.0001	198.99	199.04	0	0
244	DAve38.1	DAve38	DAve37	9.03	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.91	0.0001	199.6	199.42	0	0
245	DAve39	7St17	DAve41	111.25	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.07	0.0001	199.04	199.12	0	0
246	DAve41.1	DAve41	7St18	9.7	0.457	Circular Pipe	0.012	ADS Plastic	9.80	0.0001	199.12	198.17	0	0
247	DAve42.1	DAve42	DAve41	9.28	0.305	Circular Pipe	0.012	ADS Plastic	3.67	0.0001	199.46	199.12	0	0
248	DAve5.1	DAve5	DAve7	24.8	0.254	Circular Pipe	0.012	ADS Plastic	0.31	0.0001	201.64	201.56	0	0
249	DAve6.1	DAve6	DAve8	11.09	0.305	Circular Pipe	0.012	ADS Plastic	1.21	0.0001	201.31	201.18	0	0
250	DAve7.1	DAve7	DAve11	21.81	0.254	Circular Pipe	0.012	ADS Plastic	0.24	0.0001	201.56	201.51	0	0
251	DAve8.1	DAve8	DAve10	24.92	0.305	Circular Pipe	0.012	ADS Plastic	0.15	0.0001	201.18	201.14	0	0
252	Dit1.1	Dit1	Dit2	22.75	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.50	0.0001	207.54	207.42	0	0
253	Dit10.1	Dit10	Sal9.1	16.48	0.305	Circular Pipe	0.009	PVC Pipe	-0.75	0.0001	206.05	206.17	0	0
254	Dit3.1	Dit3	Sal13	16.39	0.305	Circular Pipe	0.009	PVC Pipe	-0.48	0.0001	206.47	206.55	0	0
255	Dit4.1	Dit4	Sal11	14.26	0.305	Circular Pipe	0.009	PVC Pipe	-0.44	0.0001	206.46	206.52	0	0
256	Dit5.1	Dit5	Dit6	54.14	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.06	0.0001	212.3	211.73	0	0
257	Dit6.1	Dit6	Dit7	41.86	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.82	0.0001	211.73	210.97	0	0
258	Dit7.1	Dit7	Dit8	13.83	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.30	0.0001	210.97	210.79	0	0
259	Dit8.1	Dit8	5St40	42.24	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	4.24	0.0001	210.79	209	0	0
260	Dit9.1	Dit9	Sal10	15.99	0.305	Circular Pipe	0.009	PVC Pipe	-0.78	0.0001	206.29	206.41	0	0
261	E1252	E1252A	Cen21	31.04	0.381	Circular Pipe	0.024	Corrugated Steel	1.00	0.0001	197.98	197.67	0.9	0
262	E1253	E1253A	E1253B	7.56	0.457	Circular Pipe	0.024	Corrugated Steel	0.54	0.0001	198.14	198.1	0.9	0
263	E1254	E1254A	E1254B	9.17	0.457	Circular Pipe	0.024	Corrugated Steel	0.56	0.0001	198.65	198.6	0.9	0
264	Eave1.2	Eave1.1	EAve1B	9.26	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.70	0.0001	202.13	202.06	0.5	0
265	EAve10.1	EAve10a	Sal24	95.62	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.10	0.0001	200.6	200.5	0	0
266	EAve12.1	3St1	EAve10a	79.34	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.40	0.0001	200.92	200.6	0	0
267	EAve13	EAve13a	EAve14a	13.38	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.18	0.0001	200.51	200.49	0	0
268	EAve14	EAve14a	4St16	22.32	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.18	0.0001	200.49	200.45	0	0
269	EAve16	4St16	EAve18A	54.37	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.18	0.0001	200.45	200.35	0	0
270	EAve17.1	EAve17	EAve18A	13.45	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	200.18	200.04	0	0

Table H-10: Conduit Information for Links 271 – 300

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
271	EAve18	EAve18A	EAve20a	84.95	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.11	0.0001	200.04	200.13	0	0
272	EAve20a.1	EAve20a	EAve22a	8.2	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	1.59	0.0001	200.13	200	0	0
273	EAve21.1	EAve21	EAve22a	13.66	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.99	0.0001	200.07	199.94	0	0
274	EAve22.1	EAve22a	EAve24	93.07	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.10	0.0001	199.77	199.68	0	0
275	EAve24.1	EAve24	EAve26	9.2	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.47	0.0001	199.68	199.64	0	0
276	EAve26.1	EAve26	EAve28	9.51	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.28	0.0001	199.64	199.61	0	0
277	EAve27.1	EAve27	EAve28	13.7	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.36	0.0001	199.56	199.61	0	0
278	EAve28.1	EAve28	EAve32	12.01	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.77	0.0001	199.61	199.7	0	0
279	EAve3.1	EAve3A	EAve3B	18.8	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.02	0.0001	201.99	201.96	0.5	0
280	EAve30.1	EAve30	EAve32	11.73	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.94	0.0001	200.05	199.7	0	0
281	EAve32.1	EAve32	EAve36	31.38	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.00	0.0001	199.7	199.7	0	0
282	EAve34.1	EAve34	EAve36	17.53	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	-1.13	0.0001	200.88	201.08	0	0
283	EAve36.1	EAve36	EAve38	44.36	0	Natural Section	0.04	Natural Section	0.32	0.0001	199.7	199.56	0	0
284	EAve38.1	EAve38	EAve42	15.79	1.054	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.18	0.0001	199.56	199.59	0.7	0.3
285	EAve39.1	EAve39	EAve40	13.9	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	3.34	0.0001	200.51	200.05	0	0
286	EAve40.1	EAve40	EAve42	12.6	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	200.05	199.92	0	0
287	EAve42.1	EAve42	EAve44	81.85	0	Natural Section	0.04	Natural Section	0.30	0.0001	199.59	199.34	0	0
288	EAve44.1	EAve44	EAve48	16.34	1.122	Circular Pipe	0.015	Reinforced Concrete Pipe	0.44	0.0001	199.34	199.27	0.7	0.3
289	EAve45.1	EAve45	EAve46	12.34	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	0.00	0.0001	200.69	200.69	0	0
290	EAve46.1	EAve46	EAve48	16.09	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	0.91	0.0001	200.69	200.54	0	0
291	EAve48.1	EAve48	EAve50	80.6	0	Natural Section	0.04	Natural Section	0.03	0.0001	199.27	199.25	0	0
292	EAve5.1	EAve5A	EAve7	36.06	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.47	0.0001	201.71	201.54	0	0
293	EAve50.1	EAve50	EAve52	17.66	1.219	Circular Pipe	0.015	Reinforced Concrete Pipe	0.06	0.0001	199.25	199.24	0.7	0.3
294	EAve52.1	EAve52	EAve58a	74.03	0	Natural Section	0.04	Natural Section	0.22	0.0001	199.24	199.0771	0	0
295	EAve54.1	EAve54	EAve56	8.32	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	4.42	0.0001	201.2	200.83	0	0
296	EAve56.1	EAve56	EAve58a	17.19	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	200.83	200.66	0	0
297	EAve58.1	EAve58a	Cen12	34.04	1.219	Box Pipe	0.015	Reinforced Concrete Pipe	3.55	1.524	199.0771	197.87	0.7	0.3
298	EAve59.1	EAve59	Cen12	24.39	0.457	Circular Pipe	0.024	Corrugated Steel	2.21	0.0001	201.59	201.05	0.9	0
299	EAve60	EAve60A	EAve60B	8.63	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.57	0.0001	201.77	201.72	0.5	0
300	EAve62	EAve62A	EAve62B	15.34	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.30	0.0001	201.84	201.79	0.5	0

Table H-11: Conduit Information for Links 301 – 330

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
301	EAve64.1	EAve64	EAve65	24.9	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.41	0.0001	201.51	201.16	0.5	0
302	EAve67	EAve67B	EAve67A	11.13	0.457	Circular Pipe	0.024	Corrugated Steel	0.47	0.0001	201.26	201.2	0.9	0
303	EAve68	EAve68B	EAve68A	15.14	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.15	0.0001	202	201.97	0.5	0
304	EAve69	EAve69B	EAve69A	17.6	0.457	Circular Pipe	0.024	Corrugated Steel	-0.32	0.0001	201.95	202.01	0.9	0
305	EAve6A.1	EAve6A	EAve6B	18.58	0.457	Circular Pipe	0.012	ADS Plastic	0.91	0.0001	202.01	201.84	0.5	0
306	EAve7.1	EAve7	EAve7B	17.2	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	-1.16	0.0001	201.54	201.74	0	0
307	EAve70	EAve70A	EAve70B	11.76	0.457	Circular Pipe	0.024	Corrugated Steel	0.72	0.0001	202.3	202.22	0.9	0
308	EAve72	EAve72B	EAve72A	23.16	0.457	Circular Pipe	0.024	Corrugated Steel	0.51	0.0001	203.51	203.39	0.9	0
309	EAve74.1	EAve74B	EAve74A	11.92	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	2.05	0.0001	203.58	203.33	0.5	0
310	EAve76.1	EAve76B	EAve76A	12.47	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	3.54	0.0001	220.48	220.03	0.5	0
311	EAve9.1	EAve9A	EAve9B	14.35	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.86	0.0001	201.64	201.51	0.5	0
312	EPl1.1	EPl1	EPl2	16.53	0.152	Circular Pipe	0.013	Ceramic Tile	-0.43	0.0001	201.67	201.74	0	0
313	EPl2.1	EPl2	Soft1	56.29	0.254	Circular Pipe	0.013	Ceramic Tile	0.43	0.0001	201.74	201.5	0	0
314	Est1	Est1A	Est1B	9.79	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.16	0.0001	211.56	211.57	0.5	0
315	Est2	Est2A	Est2B	26.9	2.6	Box Pipe	0.015	Reinforced Concrete Pipe	0.37	2.4	202.4	202.3	0.7	0.3
316	Est3.	Est3A	Est3B	18.14	0	User-Defined	0.035	Natural Section	0.61	0.0001	199.56	199.45	0.3	0.3
317	Est4.1	Est4	Est5	24.31	2.286	Circular Pipe	0.024	Corrugated Steel	0.12	0.0001	196.12	196.09	1.2	0.3
318	Est6	Est5	Est7	309.83	0.05	Natural Section	0.04	Natural Section	0.53	0.0001	196.09	194.45	0	0
319	Est7.1	Est7	Est8	63.55	0.05	Natural Section	0.04	Natural Section	0.53	0.0001	194.45	194.11	0	0
320	FAve2.1	FAve2	3St5	8.19	0.254	Circular Pipe	0.012	ADS Plastic	1.97	0.0001	201.18	201.02	0	0
321	FAve4.1	FAve4	FAve2	50.66	0.254	Circular Pipe	0.012	ADS Plastic	0.38	0.0001	201.38	201.18	0	0
322	FAve5.1	FAve5	FAve4	9.05	0.254	Circular Pipe	0.012	ADS Plastic	0.43	0.0001	201.41	201.38	0	0
323	FAve6.1	FAve6	FAve7	9.68	0.203	Circular Pipe	0.012	ADS Plastic	6.18	0.0001	201.83	201.23	0	0
324	FAve7.1	FAve7	5St13	49.94	0.356	Circular Pipe	0.012	ADS Plastic	0.87	0.0001	201.1	200.67	0	0
325	FAve8.1	FAve8	FAve11	9.25	0.254	Circular Pipe	0.012	ADS Plastic	1.61	0.0001	201.83	201.68	0	0
326	FAve9.1	FAve9	FAve11	18.49	0.254	Circular Pipe	0.012	ADS Plastic	0.97	0.0001	201.86	201.68	0	0
327	FPl1.1	FPl1	Sal23	78.35	0.457	Circular Pipe	0.012	ADS Plastic	0.55	0.0001	200.36	199.93	0	0
328	FPl11.1	FPl11	FPl6	57.36	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.99	0.0001	201.35	200.78	0	0
329	FPl12.1	FPl12	FPl11	9.21	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	0.80	0.0001	201.42	201.35	0	0
330	FPl13.1	FPl13	FPl11	121.46	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.72	0.0001	202.22	201.35	0	0

Table H-12: Conduit Information for Links 331 – 360

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
331	FPl14.1	FPl14	FPl13	9.21	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	1.78	0.0001	202.39	202.22	0	0
332	FPl3.1	FPl4	FPl1	9.76	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.72	0.0001	200.53	200.36	0	0
333	FPl5.1	FPl6	FPl5	9.28	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	200.78	200.69	0	0
334	FPl6.1	FPl8	FPl6	38.28	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.39	0.0001	201.31	200.78	0	0
335	FPl7.1	FPl7	FPl8	10.73	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	201.42	201.31	0	0
336	FPl8.1	FPl10	FPl8	113.14	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.49	0.0001	201.87	201.31	0	0
337	FPl9.1	FPl9	FPl10	10.45	0.406	Circular Pipe	0.015	Reinforced Concrete Pipe	0.56	0.0001	201.93	201.87	0	0
338	GAve2.1	GAve2	5St14	50.63	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.50	0.0001	202.07	201.31	0	0
339	GAve3.1	GAve3	GAve2	9.04	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.70	0.0001	201.83	201.76	0	0
340	HAve1.1	HAve2	HAve1	9.06	0.305	Circular Pipe	0.012	ADS Plastic	3.48	0.0001	206.16	205.85	0	0
341	HAve10.1	HAve10	HAve8	14.68	0.203	Circular Pipe	0.012	ADS Plastic	0.30	0.0001	205.57	205.53	0	0
342	HAve11.1	HAve11	HAve9	8.51	0.356	Circular Pipe	0.012	ADS Plastic	1.78	0.0001	205.3	205.15	0	0
343	HAve12.1	HAve12	HAve11	8.99	0.305	Circular Pipe	0.012	ADS Plastic	1.48	0.0001	205.43	205.3	0	0
344	HAve13	HAve9	HAve15	73.88	0.61	Circular Pipe	0.012	ADS Plastic	0.44	0.0001	205.15	204.82	0	0
345	HAve15.1	HAve15	Cen5	75.05	0.61	Circular Pipe	0.012	ADS Plastic	0.03	0.0001	204.82	204.8	0	0
346	HAve17.1	HAve17	Cen5	21.22	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	205.64	205.43	0	0
347	HAve18.1	HAve18	HAve17	9.09	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	2.67	0.0001	205.89	205.64	0	0
348	HAve19.1	HAve19	Cen5	64.24	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	205.32	204.68	0	0
349	HAve2.1	4St23	HAve2	102.08	0.254	Circular Pipe	0.012	ADS Plastic	0.78	0.0001	206.96	206.16	0	0
350	HAve20.1	HAve20	HAve19	10.53	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	4.01	0.0001	205.74	205.32	0	0
351	HAve21.1	HAve21	HAve19	85.54	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.10	0.0001	205.41	205.32	0	0
352	HAve22.1	HAve22	HAve21	9.02	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.00	0.0001	205.4	205.4	0	0
353	HAve24.1	HAve24	HAve22	15.73	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.00	0.0001	205.4	205.4	0	0
354	HAve26.1	HAve26	HAve24	94.91	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.06	0.0001	206.51	205.5	0	0
355	HAve28.1	HAve28	HAve26	13.34	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	206.64	206.51	0	0
356	HAve3.1	HAve3	HAve5	67.26	0.61	Circular Pipe	0.012	ADS Plastic	0.10	0.0001	205.51	205.44	0	0
357	HAve5.1	HAve7	HAve5	8.32	0.305	Circular Pipe	0.012	ADS Plastic	0.08	0.0001	205.45	205.44	0	0
358	HAve8.1	HAve8	HAve7	9.06	0.254	Circular Pipe	0.012	ADS Plastic	0.81	0.0001	205.53	205.45	0	0
359	HAve9.1	HAve5	HAve9	62.92	0.61	Circular Pipe	0.012	ADS Plastic	0.47	0.0001	205.44	205.15	0	0
360	HHoutlet.1	HHoutlet	Sal21	398.95	0.305	Circular Pipe	0.012	ADS Plastic	0.30	0.0001	201.42	200.24	0	0

Table H-13: Conduit Information for Links 361 – 390

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
361	HW110	HW110B	HW110A	40.1	0.914	Circular Pipe	0.012	ADS Plastic	0.14	0.0001	198.25	198.2	0.5	0
362	HW112	HW112B	HW112A	19.08	0.61	Circular Pipe	0.024	Corrugated Steel	0.04	0.0001	199.21	199.21	0.9	0
363	HW114	HW114B	HW114A	13.02	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.57	0.0001	199.88	199.68	0.5	0
364	HW116	HW116B	HW116A	11.06	0.457	Circular Pipe	0.024	Corrugated Steel	1.33	0.0001	201.99	201.84	0.9	0
365	HW117	HW117A	HW117B	20.24	0.356	Circular Pipe	0.012	ADS Plastic	-0.63	0.0001	202.35	202.47	0.5	0
366	HW119	HW119A	HW119B	17.92	0.381	Circular Pipe	0.012	ADS Plastic	0.70	0.0001	202.24	202.12	0.5	0
367	HW12	HW12B	HW12A	14.03	1.016	Circular Pipe	0.012	ADS Plastic	0.70	0.0001	197.35	197.25	0.9	0
368	HW14	HW14B	HW14A	13.43	0.889	Circular Pipe	0.015	Reinforced Concrete Pipe	0.62	0.0001	197.48	197.39	0.5	0
369	HW16	HW16B	HW16A	24.15	0.813	Circular Pipe	0.012	ADS Plastic	0.05	0.0001	198.15	198.14	0.5	0
370	HW18	HW18B	HW110A	38.39	0.356	Circular Pipe	0.024	Corrugated Steel	0.63	0.0001	199.22	198.98	0.9	0
371	HW20A.1	HW20A	HW20B	11.4	1.463	Box Pipe	0.015	Reinforced Concrete Pipe	6.53	0.6096	228.79	228.04	0.7	0
372	HW20B.1	HW20B	HW20C	10.11	1.463	Box Pipe	0.015	Reinforced Concrete Pipe	6.60	0.6096	227.65	226.98	0	0
373	HW20C.1	HW20C	HW20D	10.12	1.463	Box Pipe	0.015	Reinforced Concrete Pipe	6.60	0.6096	226.58	225.92	0	0
374	HW21	HW21A	HW21B	21.27	1.829	Box Pipe	0.015	Reinforced Concrete Pipe	0.81	1.2192	229.15	228.97	0.7	0
375	JAve10.1	JAve10	JAve8	14.58	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	2.19	0.0001	216.08	215.76	0	0
376	JAve12	JAve8	JAve14	68.28	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.05	0.0001	215.76	215.72	0	0
377	JAve14.1	JAve14	JAve16	33.34	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.91	0.0001	215.72	215.42	0	0
378	JAve15.1	JAve15	JAve19	19.8	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	3.40	0.0001	215.29	214.62	0	0
379	JAve16.1	JAve16	JAve18	8.57	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.72	0.0001	215.42	215.27	0	0
380	JAve18.1	JAve18	JAve19	17.91	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	3.67	0.0001	215.27	214.62	0	0
381	JAve2.1	JAve2	Sal17	15.84	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	204.42	204.26	0	0
382	Jave20.1	JAve22	JAve18	9.04	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	215.36	215.27	0	0
383	JAve22.1	JAve24	JAve22	79.08	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.28	0.0001	217.17	215.36	0	0
384	JAve24.1	JAve26	JAve24	9.03	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	4.65	0.0001	217.59	217.17	0	0
385	JAve28.1	JAve28	JAve30	9.03	0.305	Circular Pipe	0.012	ADS Plastic	0.69	0.0001	212.62	212.56	0	0
386	JAve3.1	JAve3	Sal16	110.08	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	205.72	204.62	0	0
387	JAve30.1	JAve30	Cen1	56.68	0.305	Circular Pipe	0.012	ADS Plastic	3.69	0.0001	212.56	210.47	0	0
388	JAve32	JAve34	Cen1	133.04	0.457	Circular Pipe	0.012	ADS Plastic	2.90	0.0001	214.18	210.32	0	0
389	JAve34.1	JAve36	JAve34	10.05	0.356	Circular Pipe	0.012	ADS Plastic	8.97	0.0001	215.08	214.18	0	0
390	JAve36.1	JAve38	JAve36	92.68	0.406	Circular Pipe	0.012	ADS Plastic	7.25	0.0001	221.8	215.08	0	0

Table H-14: Conduit Information for Links 391 – 420

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
391	JAve38.1	JAve40	JAve38	9.28	0.406	Circular Pipe	0.012	ADS Plastic	4.77	0.0001	222.25	221.8	0	0
392	JAve4.1	JAve4	JAve3	8.88	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	205.81	205.72	0	0
393	JAve5.1	JAve5	5St22	94.6	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.35	0.0001	215.28	214.01	0	0
394	JAve6.1	JAve6	JAve5	21.12	0.203	Circular Pipe	0.015	Reinforced Concrete Pipe	4.03	0.0001	216.14	215.28	0	0
395	JAve7.1	JAve7	JAve5	19.06	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.34	0.0001	215.54	215.28	0	0
396	JAve8.1	JAve8	JAve7	9.02	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	2.43	0.0001	215.76	215.54	0	0
397	Jpl1.1	Jpl1	Jpl2	9.4	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	3.56	0.0001	211.27	210.93	0	0
398	Jpl2.1	Jpl2	JPl2B	104.19	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	210.93	209.89	0	0
399	JW1	JW1A	JW1B	20.53	1.28	Box Pipe	0.015	Reinforced Concrete Pipe	0.57	2.438	216.05	215.93	0.4	0
400	JW2	JW2A	JW2B	13.52	2.195	Box Pipe	0.015	Reinforced Concrete Pipe	3.34	1.8288	215.98	215.53	0.4	0
401	KAve1.1	KAve1	KAve2	9.03	0.305	Circular Pipe	0.012	ADS Plastic	5.19	0.0001	215.59	215.12	0	0
402	KAve11.1	KAve11	KAve10	8.97	0.356	Circular Pipe	0.012	ADS Plastic	2.06	0.0001	220.98	220.8	0	0
403	KAve12	MAve4	KAve8	159.61	0.356	Circular Pipe	0.012	ADS Plastic	3.03	0.0001	225.52	220.69	0	0
404	KAve2.1	KAve2	KAve4	11.45	0.305	Circular Pipe	0.012	ADS Plastic	1.75	0.0001	215.12	214.92	0	0
405	KAve4.1	KAve4	Cen1	97.81	0.356	Circular Pipe	0.012	ADS Plastic	4.60	0.0001	214.92	210.42	0	0
406	KAve6	KAve8	KAve4	155.28	0.356	Circular Pipe	0.012	ADS Plastic	3.71	0.0001	220.69	214.92	0	0
407	KAve8.1	KAve10	KAve8	10.96	0.356	Circular Pipe	0.012	ADS Plastic	1.00	0.0001	220.8	220.69	0	0
408	KCt1.1	Kct1	Dit8	43.84	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	12.34	0.0001	216.2	210.79	0	0
409	MAve1.1	MAve1	MAve2	10.87	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.88	0.0001	212.34	212.13	0	0
410	MAve2.1	MAve2	5St48	55.84	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	6.58	0.0001	212.13	208.46	0	0
411	MAve3.1	MAve3	MAve4	9	0.305	Circular Pipe	0.012	ADS Plastic	2.38	0.0001	225.73	225.52	0	0
412	Mercy1.1	Mercy1	3St1	9.34	0.203	Circular Pipe	0.013	Ceramic Tile	1.70	0.0001	201.25	201.09	0	0
413	Mercy2.1	Mercy2	Mercy1	7.31	0.152	Circular Pipe	0.013	Ceramic Tile	4.97	0.0001	201.61	201.25	0	0
414	Mercy3.1	Mercy3	Mercy1	11.98	0.152	Circular Pipe	0.013	Ceramic Tile	4.14	0.0001	201.74	201.25	0	0
415	Mercy4.1	Mercy4	Mercy1	29.72	0.203	Circular Pipe	0.013	Ceramic Tile	1.70	0.0001	201.75	201.25	0	0
416	NAve1.1	NAve3	NAve1	13.19	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	207.11	206.97	0	0
417	NAve3.1	NAve5	NAve3	69.72	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.67	0.0001	207.57	207.11	0	0
418	NAve4.1	NAve4	NAve3	12.11	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.61	0.0001	207.42	207.11	0	0
419	NAve6.1	NAve6	NAve5	12.27	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	1.20	0.0001	207.72	207.57	0	0
420	NMap1	NMap1A	NMap1B	15.89	0.991	Box Pipe	0.015	Reinforced Concrete Pipe	5.10	1.2192	212.04	211.23	0.4	0

Table H-15: Conduit Information for Links 421 – 450

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
421	NMAp2	NMap2A	NMap2B	13.45	1.295	Box Pipe	0.015	Reinforced Concrete Pipe	2.46	1.524	212.43	212.1	0.4	0
422	NMap3	NMap3A	NMap3B	15.23	0.813	Circular Pipe	0.024	Corrugated Steel	2.55	0.0001	217.05	216.67	0.5	0
423	NMap4	NMap4A	NMap4B	19.6	1.524	Box Pipe	0.015	Reinforced Concrete Pipe	0.47	3.048	214.51	214.42	0.4	0
424	NNut1A.1	NNut1A	NNut1B	12.87	1.016	Box Pipe	0.015	Reinforced Concrete Pipe	2.87	0.9144	223.71	223.34	0.4	0
425	NNut1B.1	NNut1B	NNut1C	7.02	0.762	Box Pipe	0.015	Reinforced Concrete Pipe	20.85	0.9144	223.34	221.88	0	0
426	NNut2	NNut2B	NNut2A	12.41	0.61	Circular Pipe	0.024	Corrugated Steel	2.61	0.0001	223.48	223.15	0.9	0
427	NNut3	NNut3B	NNut3A	9.12	0.787	Circular Pipe	0.015	Reinforced Concrete Pipe	0.91	0.0001	224.27	224.18	0.5	0
428	NNut5	NNut5A	NNut5B	12.15	0.787	Circular Pipe	0.015	Reinforced Concrete Pipe	0.58	0.0001	225.01	224.94	0.5	0
429	NNut6	NNut6A	NNut6B	10.51	1.575	Circular Pipe	0.024	Corrugated Steel	0.72	0.0001	219.9	219.82	0	0
430	Pk1.1	Pk2	Pk1	8.05	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.00	0.0001	199.82	199.66	0	0
431	Pk3	Pk4	Pk1	35.7	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.20	0.0001	199.44	199.37	0	0
432	Pk5.1	Pk5	Pk4	26.27	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.81	0.0001	199.73	199.52	0	0
433	Pk6	Pk7	Pk4	27.27	0.381	Circular Pipe	0.015	Reinforced Concrete Pipe	0.20	0.0001	199.5	199.44	0	0
434	PK7.1	DAve27	Pk7	22.98	0.381	Circular Pipe	0.015	Reinforced Concrete Pipe	0.17	0.0001	199.54	199.5	0	0
435	Pond1	Pond1A	Pond1B	22.13	0.152	Circular Pipe	0.009	PVC Pipe	9.58	0.0001	216.15	214.03	0	0
436	Prie1.1	Prie1	Prie2	29.57	0.381	Circular Pipe	0.012	ADS Plastic	0.57	0.0001	200	200	0	0
437	Prie2.1	Prie2	Prie3	19.37	0.381	Circular Pipe	0.012	ADS Plastic	0.61	0.0001	200	200	0	0
438	Prie3.1	Prie3	Prie4	19.6	0.381	Circular Pipe	0.012	ADS Plastic	1.75	0.0001	200	200	0	0
439	Prie4.1	Prie4	Prie5	13.86	0.381	Circular Pipe	0.012	ADS Plastic	-0.87	0.0001	200	200	0	0
440	Prie5.1	Prie5	Cen6a	17.45	0.203	Circular Pipe	0.012	ADS Plastic	0.47	0.0001	200	200	0	0
441	PV1	PV3	Sal21	47.99	0.457	Circular Pipe	0.012	ADS Plastic	0.99	0.0001	202.7	202.23	0	0
442	PV10.1	PV10	PV9	40.19	0.203	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	203.96	203.56	0	0
443	PV12.1	PV12	PV9	20.29	0.203	Circular Pipe	0.009	PVC Pipe	0.50	0.0001	203.66	203.56	0	0
444	PV14.1	PV14a	PV12	36.72	0.203	Circular Pipe	0.009	PVC Pipe	0.02	0.0001	203.67	203.66	0	0
445	PV16.1	PV16a	PV14a	30.13	0.203	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	203.97	203.67	0	0
446	PV18.1	PV18	PV16a	10.76	0.203	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	204.08	203.97	0	0
447	PV2.1	PV2	PV3	11.15	0.457	Circular Pipe	0.012	ADS Plastic	2.06	0.0001	202.93	202.7	0	0
448	PV20.1	PV20	PV18	42.2	0.203	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	204.5	204.08	0	0
449	PV22.1	PV22	PV16a	33.2	0.203	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	204.3	203.97	0	0
450	PV24.1	PV24	PV22	61.4	0.203	Circular Pipe	0.009	PVC Pipe	1.00	0.0001	204.92	204.3	0	0

Table H-16: Conduit Information for Links 451 – 480

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
451	PV26.1	PV26	PV6	66.51	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.96	0.0001	205.15	203.18	0	0
452	PV28.1	3Pl1	PV26	117.25	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.96	0.0001	208.62	205.15	0	0
453	PV4.1	PV4	Sal20	128.44	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.00	0.0001	203.07	201.79	0	0
454	PV6.1	PV6	PV4	21.08	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.51	0.0001	203.18	203.07	0	0
455	PV7.1	PV7	PV6	16.63	0.356	Circular Pipe	0.024	Corrugated Steel	11.08	0.0001	205.02	203.18	0.9	0
456	PV9.1	PV9	PV6	140.51	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.27	0.0001	203.56	203.18	0	0
457	RRSD1.1	RRSD1	Cen18	393.71	0.203	Circular Pipe	0.009	PVC Pipe	0.45	0.0001	199.33	197.56	0	0
458	Sal1.1	Sal1	Sal2	14.5	1.749	Weir	0.015	Reinforced Concrete Pipe	0.08	5	208.89	208.88	0	0
459	Sal10.1	Sal10	Sal11	81.82	0	Natural Section	0.04	Natural Section	0.39	0.0001	204.87	204.55	0	0
460	Sal11.1	Sal11	Sal12	41.31	0.05	Natural Section	0.04	Natural Section	0.39	0.0001	204.55	204.39	0	0
461	Sal12.1	Sal12	Sal13	31.53	0	Natural Section	0.04	Natural Section	0.67	0.0001	204.39	204.18	0	0
462	Sal13.1	Sal13	Sal14	285.42	0	Natural Section	0.04	Natural Section	0.67	0.0001	204.18	202.26	0	0
463	Sal14.1	Sal14	Sal15	9.82	0	Natural Section	0.04	Natural Section	0.03	0.0001	202.26	202.26	0	0
464	Sal15.1	Sal15	Sal16	47.11	0	Natural Section	0.04	Natural Section	0.39	0.0001	202.26	202.07	0	0
465	Sal16.1	Sal16	Sal17	61.1	0	Natural Section	0.04	Natural Section	0.38	0.0001	202.07	201.84	0	0
466	Sal17.1	Sal17	Sal18	159.45	0	Natural Section	0.04	Natural Section	0.39	0.0001	201.84	201.22	0	0
467	Sal18.1	Sal18	Sal19	46.71	0	Natural Section	0.04	Natural Section	0.39	0.0001	201.22	201.04	0	0
468	Sal19.1	Sal19	Sal20	19.18	0	Natural Section	0.04	Natural Section	0.39	0.0001	201.04	200.97	0	0
469	Sal2.1	Sal2	Sal3.1	208.7	0	Natural Section	0.04	Natural Section	0.18	0.0001	208.31	207.93	0	0
470	Sal20.1	Sal20	Sal21	188.11	0	Natural Section	0.04	Natural Section	0.39	0.0001	200.97	200.24	0	0
471	Sal21.1	Sal21	Sal22	93.58	0	Natural Section	0.04	Natural Section	0.39	0.0001	200.24	199.87	0	0
472	Sal22.1	Sal22	Sal23	246.33	0	Natural Section	0.04	Natural Section	0.24	0.0001	199.87	199.28	0	0
473	Sal23.1	Sal23	Sal24	71.4	0	Natural Section	0.04	Natural Section	0.23	0.0001	199.28	199.12	0	0
474	Sal24.1	Sal24	Sal25	22.07	0	User-Defined	0.014	Natural Section	0.10	0.0001	199.12	199.1	0.3	0.3
475	Sal25.1	Sal25	Sal26	108.17	0	Natural Section	0.04	Natural Section	0.12	0.0001	199.1	198.97	0	0
476	Sal26.1	Sal26	Sal27	33.71	0.05	Natural Section	0.04	Natural Section	0.12	0.0001	198.97	198.93	0	0
477	Sal27.1	Sal27	Sal28	45.36	0.05	Natural Section	0.04	Natural Section	0.11	0.0001	198.93	198.88	0	0
478	Sal28.1	Sal28	Sal29	20.73	3.168	User-Defined	0.015	Reinforced Concrete Pipe	0.92	4.2672	198.88	198.69	0.7	0.7
479	Sal29.1	Sal29	Sal30	40.639	0	Natural Section	0.04	Natural Section	-0.22	0.0001	198.69	198.78	0	0
480	Sal3	Sal3.1	Sal4.1	188.27	0	Natural Section	0.04	Natural Section	0.09	0.0001	207.93	207.76	0	0

Table H-17: Conduit Information for Links 481 – 510

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
481	Sal30.1	Sal30	Sal31	40.64	0	Natural Section	0.04	Natural Section	-0.21	0.0001	198.78	198.86	0	0
482	Sal31.1	Sal31	Sal32	20.73	2.336	User-Defined	0.015	Reinforced Concrete Pipe	0.14	4.2672	198.86	198.83	0.7	0.7
483	Sal32.1	Sal32	Sal33	57.6	0.05	Natural Section	0.04	Natural Section	1.05	0.0001	199.1	198.49	0	0
484	Sal33.1	Sal33	Sal34	39.21	0.05	Natural Section	0.04	Natural Section	1.05	0.0001	198.23	197.82	0	0
485	Sal34.1	Sal34	Sal35	17.68	2.896	User-Defined	0.015	Reinforced Concrete Pipe	-0.17	4.2672	197.82	197.85	0.7	0.7
486	Sal35.1	Sal35	Sal36	178.07	0	Natural Section	0.04	Natural Section	0.47	0.0001	197.85	197.01	0	0
487	Sal36.1	Sal36	Sal37	186.06	0	Natural Section	0.04	Natural Section	0.29	0.0001	197.01	196.46	0	0
488	Sal37.1	Sal37	Sal38	130.31	0	Natural Section	0.04	Natural Section	0.29	0.0001	196.46	196.08	0	0
489	Sal38.1	Sal38	Sal39	220.7	0	Natural Section	0.04	Natural Section	0.36	0.0001	196.08	195.28	0	0
490	Sal39.1	Sal39	Sal40	6.68	0	Natural Section	0.04	Natural Section	-1.47	0.0001	195.28	195.38	0	0
491	Sal4	Sal4.1	Sal5.1	6.35	3.634	Natural Section	0.04	Natural Section	10.41	0.0001	207.76	207.1	0	0
492	Sal40.1	Sal40	Sal41	65.45	0	Natural Section	0.04	Natural Section	0.06	0.0001	195.38	195.34	0	0
493	Sal41.1	Sal41	Sal42	233.35	0	Natural Section	0.04	Natural Section	0.03	0.0001	195.34	195.28	0	0
494	Sal42.1	Sal42	Sal43	8.85	0	Natural Section	0.04	Natural Section	3.75	0.0001	195.28	194.95	0	0
495	Sal43.1	Sal43	Sal44	56.98	0	Natural Section	0.04	Natural Section	1.61	0.0001	194.95	194.03	0	0
496	Sal44.1	Sal44	Sal45	254.92	0	Natural Section	0.04	Natural Section	0.17	0.0001	194.03	193.6	0	0
497	Sal45.1	Sal45	Sal46	10	0	Natural Section	0.04	Natural Section	0.00	0.0001	193.6	193.52	0	0
498	Sal5	Sal5.1	Sal6.1	172.06	0	Natural Section	0.04	Natural Section	0.65	0.0001	207.1	205.98	0	0
499	Sal6	Sal6.1	Sal7.1	251.9	0	Natural Section	0.04	Natural Section	0.14	0.0001	205.98	205.62	0	0
500	Sal7	Sal7.1	Sal8.1	48.97	0	Natural Section	0.04	Natural Section	0.14	0.0001	205.62	205.55	0	0
501	Sal8	Sal8.1	Sal9.1	93.72	0.05	Natural Section	0.04	Natural Section	0.39	0.0001	205.55	205.18	0	0
502	Sal9	Sal9.1	Sal10	80.88	0	Natural Section	0.04	Natural Section	0.39	0.0001	205.18	204.87	0	0
503	Sch1.1	Sch1	6St22	42.95	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.04	0.0001	200.34	200.32	0	0
504	Sch2.1	Sch2	Sch1	138.65	0.152	Circular Pipe	0.009	PVC Pipe	1.67	0.0001	202.66	200.34	0	0
505	Sch3.1	Sch3	Sch2	26.94	0.152	Circular Pipe	0.009	PVC Pipe	-0.71	0.0001	202.47	202.66	0	0
506	Sch4.1	Sch4	Sch1	42.43	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.04	0.0001	200.36	200.34	0	0
507	Sch5.1	Sch5	Sch4	89.43	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.55	0.0001	200.85	200.36	0	0
508	Sch6.1	Sch6	Sch5	49.88	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.12	0.0001	200.79	200.85	0	0
509	SMap1.1	SMap1	SMap1B	25.24	1.524	Circular Pipe	0.024	Corrugated Steel	-0.61	0.0001	197.28	197.44	0.5	0
510	SMap11.1	SMap11	SMap9	32.58	0.914	Circular Pipe	0.024	Corrugated Steel	0.37	0.0001	197.77	197.65	0.9	0

Table H-18: Conduit Information for Links 510 – 540

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
511	SMap12.1	SMap12A	SMap12B	10.23	0.61	Circular Pipe	0.024	Corrugated Steel	1.68	0.0001	197.89	197.72	0.9	0
512	SMap14.1	SMap14A	SMap14B	13.96	0.61	Circular Pipe	0.024	Corrugated Steel	-0.29	0.0001	197.93	197.97	0.9	0
513	SMap16.1	SMap16	SMap16B	17.54	0.457	Circular Pipe	0.012	ADS Plastic	-0.73	0.0001	198.41	198.54	0	0
514	SMap17.1	SMap17A	SMap17B	8.45	0.914	Circular Pipe	0.024	Corrugated Steel	0.39	0.0001	198.17	198.14	0.5	0
515	SMap18.1	SMap18	SMap16	31.73	0.305	Circular Pipe	0.012	ADS Plastic	-0.22	0.0001	198.5	198.56	0	0
516	SMap20.1	SMap20	SMap18	24.26	0.305	Circular Pipe	0.012	ADS Plastic	-0.05	0.0001	198.48	198.5	0	0
517	SMap21.1	SMap21A	SMap21B	38.93	0.914	Circular Pipe	0.024	Corrugated Steel	0.33	0.0001	198.44	198.31	0.9	0
518	SMap22	SMap24	SMap20	42.25	0.305	Circular Pipe	0.012	ADS Plastic	0.24	0.0001	198.59	198.48	0	0
519	SMap24.1	SMap26	SMap24	9.92	0.305	Circular Pipe	0.012	ADS Plastic	0.49	0.0001	198.63	198.59	0	0
520	SMap27.1	SMap27	SMap27B	23.98	0.914	Circular Pipe	0.024	Corrugated Steel	0.70	0.0001	198.55	198.38	0	0
521	SMap28.1	SMap28	SMap26	21.33	0.305	Circular Pipe	0.012	ADS Plastic	0.29	0.0001	198.7	198.63	0	0
522	SMap3.1	SMap3	SMap1	7	0.61	Circular Pipe	0.024	Corrugated Steel	2.66	0.0001	197.47	197.28	0	0
523	SMap30.1	SMap30	SMap28	10.88	0.305	Circular Pipe	0.012	ADS Plastic	-0.54	0.0001	198.64	198.7	0	0
524	SMap31.1	AAve11	SMap27	42.77	0.914	Circular Pipe	0.024	Corrugated Steel	-0.14	0.0001	198.49	198.55	0	0
525	SMap4	SMap4A	SMap4B	22.48	0.61	Circular Pipe	0.024	Corrugated Steel	0.48	0.0001	198.51	198.4	0.9	0
526	SMap5.1	SMap5	SMap5B	37.5	0.914	Circular Pipe	0.024	Corrugated Steel	-0.26	0.0001	197.55	197.65	0	0
527	SMap6.1	SMap6	SMap6B	68.78	0.61	Circular Pipe	0.024	Corrugated Steel	-0.32	0.0001	197.99	198.21	0.9	0
528	SMap7.1	SMap9	SMap5	44.07	0.914	Circular Pipe	0.024	Corrugated Steel	0.22	0.0001	197.65	197.55	0	0
529	SMap9.1	SMap9	SMap6	19.44	0.61	Circular Pipe	0.024	Corrugated Steel	-1.10	0.0001	197.65	197.86	0	0
530	SNut1.1	SNut1A	SNut1B	17.52	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.86	0.0001	200.27	200.12	0.9	0
531	SNut10	SNut10A	SNut10B	11.18	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.21	0.0001	199.93	199.91	0.5	0
532	SNut11	SNut11A	SNut11B	12.3	0.457	Circular Pipe	0.024	Corrugated Steel	0.16	0.0001	199.91	199.89	0.9	0
533	SNut13	SNut13A	SNut13B	9.83	0.457	Circular Pipe	0.024	Corrugated Steel	1.13	0.0001	200.12	200.01	0.9	0
534	SNut15	SNut15A	SNut15B	9.3	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.86	0.0001	200.45	200.37	0.9	0
535	SNut17	SNut17A	SNut17B	83.46	0.457	Circular Pipe	0.012	ADS Plastic	0.32	0.0001	200.98	200.72	0.9	0
536	SNut18	SNut18A	SNut18B	11.84	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.50	0.0001	200	200	0.5	0
537	SNut3.1	SNut3	SNut3B	12.89	0.61	Circular Pipe	0.024	Corrugated Steel	0.91	0.0001	199.35	199.24	0.9	0
538	SNut4.1	SNut4	SNut6	13.56	0.457	Circular Pipe	0.024	Corrugated Steel	0.61	0.0001	199.6	199.51	0.9	0
539	SNut6.1	SNut6	SNut3	18.49	0.61	Circular Pipe	0.024	Corrugated Steel	0.86	0.0001	199.51	199.35	0.9	0
540	SNut7	SNut7A	SNut7B	12.32	0.457	Circular Pipe	0.024	Corrugated Steel	1.15	0.0001	199.79	199.65	0.9	0

Table H-19: Conduit Information for Links 541 – 570

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
541	SNut8	SNut8B	SNut8A	19.17	0.457	Circular Pipe	0.024	Corrugated Steel	-0.74	0.0001	199.84	199.98	0.9	0
542	SNut9	SNut9A	SNut9B	16.67	0.457	Circular Pipe	0.024	Corrugated Steel	-0.04	0.0001	199.82	199.83	0.9	0
543	Soft2	Soft1	Cen8	91.18	0.508	Circular Pipe	0.024	Corrugated Steel	0.08	0.0001	201.5	201.42	0	0
544	Soft3	FAve11	Soft1	118.83	0.406	Circular Pipe	0.012	ADS Plastic	0.15	0.0001	201.68	201.5	0	0
545	UPSal1	UPSal2	Sal1	162.43	0.305	Circular Pipe	0.012	ADS Plastic	0.79	0.0001	210.51	209.22	0	0
546	UPSal2.1	UPSal3	UPSal2	81.62	0.203	Circular Pipe	0.024	Corrugated Steel	0.84	0.0001	211.2	210.51	0	0
547	UPSal3.1	UPSal4	UPSal2	455.1	0.305	Circular Pipe	0.012	ADS Plastic	0.63	0.0001	213.37	210.51	0	0
548	UPSal4.1	UPSal5	UPSal4	135.39	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.31	0.0001	213.79	213.37	0	0
549	UPSal5.1	UPSal6	UPSal4	255.62	0.203	Circular Pipe	0.013	Ceramic Tile	0.63	0.0001	214.98	213.37	0	0
550	W1251	W1251A	W1251B	31.89	1.524	Circular Pipe	0.024	Corrugated Steel	0.08	0.0001	196.87	196.85	0.9	0
551	W1252.1	W1252	Cen22	25.71	1.524	Circular Pipe	0.024	Corrugated Steel	0.97	0.0001	196.82	196.57	0.5	0
552	W2St2	W2ndSt2	W2St1	7.45	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.64	0.0001	203.23	203.11	0	0
553	W2St3.1	W2St1	W2St3	63.91	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.79	0.0001	203.11	202.61	0	0
554	W2St4.1	W2St4	W2St3	7.35	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.41	0.0001	202.71	202.61	0	0
555	W2St6.1	W2St6	W2St5	7.45	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.95	0.0001	203.01	202.86	0	0
556	W2St7.1	W2St7	W2St5	94.62	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	0.41	0.0001	203.25	202.86	0	0
557	W2St8.1	W2St8	W2St7	7.3	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	3.34	0.0001	203.5	203.25	0	0
558	W3rdSt1.1	W3St3	W3St1B	37.31	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.95	0.0001	202.41	202.05	0	0
559	W3St3.1	W3St4	W3St3	9.19	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.47	0.0001	202.54	202.41	0	0
560	W3St6.1	W3St6	WHAve15	9.13	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.22	0.0001	202.43	202.45	0	0
561	W3St8	W3rdSt8	W3rdSt7	9.08	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	1.08	0.0001	202.66	202.56	0	0
562	W4st3	W4th3	W4th2	9.12	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	2.15	0.0001	202.54	202.34	0	0
563	W4th2.1	W4th2	W4th2B	59.54	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.42	0.0001	202.34	202.09	0	0
564	WHAve1.1	WHAve1	WHAve1B	45.75	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.86	0.0001	202.57	202.17	0	0
565	WHAve10.1	WHAve10	WHAve8	69.52	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	0.40	0.0001	202.56	202.28	0.5	0
566	WHAve11.1	WHAve11	WHAve11B	34.85	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	0.45	0.0001	202.31	202.15	0	0
567	WHAve12.1	WHAve12	WHAve11	12.34	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.57	0.0001	202.38	202.31	0	0
568	WHAve14	W3rdSt7	WHAve12	14.23	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.30	0.0001	202.56	202.38	0	0
569	WHAve15.1	WHAve15	WHAve11	15.83	0.356	Circular Pipe	0.015	Reinforced Concrete Pipe	0.23	0.0001	202.35	202.31	0	0
570	WHAve17.1	WHAve17	WHAve11	62.05	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.07	0.0001	202.27	202.31	0	0

Table H-20: Conduit Information for Links 570 – 596

Number	Link	Upstream Node	Downstream Node	Length (m)	Diameter (m)	Conduit Shape	Roughness	Material	Slope (%)	Width (m)	Upstream Invert Elevation (m)	Downstream Invert Elevation (m)	Entrance Loss	Exit Loss
571	WHAve18.1	WHAve18	WHAve17	12.55	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	0.72	0.0001	202.39	202.3	0	0
572	WHAve20.1	WHAve20	WHAve18	8.37	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	2.59	0.0001	202.61	202.39	0	0
573	WHAve22.1	WHAve22	WHAve20	82.08	0.254	Circular Pipe	0.015	Reinforced Concrete Pipe	0.25	0.0001	202.82	202.61	0	0
574	WHAve23	W2St3	WHAve17	41.46	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	0.73	0.0001	202.61	202.3	0	0
575	WHAve24	W2St5	WHAve18	41.53	0.457	Circular Pipe	0.015	Reinforced Concrete Pipe	1.13	0.0001	202.86	202.39	0	0
576	WHAve25.1	WHAve25	W2St4	43.73	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	1.52	0.0001	203.37	202.71	0	0
577	WHAve26.1	WHAve26	WHAve25	12.27	0.61	Circular Pipe	0.015	Reinforced Concrete Pipe	0.53	0.0001	203.44	203.37	0	0
578	WHAve28.1	WHave28	WHAve26	9.1	0.61	Circular Pipe	0.012	ADS Plastic	0.90	0.0001	203.52	203.44	0.5	0
579	WHAve29.1	WHave29	WHAve25	15.62	0.381	Circular Pipe	0.012	ADS Plastic	1.25	0.0001	203.81	203.61	0	0
580	WHAve3.1	WHAve3	WHAve1	12.32	0.305	Circular Pipe	0.015	Reinforced Concrete Pipe	1.36	0.0001	202.74	202.57	0	0
581	WHAve31.1	WhAve31	WHave29	15.06	0.381	Circular Pipe	0.012	ADS Plastic	6.73	0.0001	204.82	203.81	0	0
582	WHAve33.1	WHAve33	WHAve25	64.79	0.305	Circular Pipe	0.012	ADS Plastic	1.05	0.0001	204.32	203.64	0	0
583	WHAve35.1	WHAve35	WHave29	62.11	0.381	Circular Pipe	0.012	ADS Plastic	0.19	0.0001	203.93	203.81	0.5	0
584	WHAve4.1	WHAve4	WHAve3	8.97	0.305	Circular Pipe	0.012	ADS Plastic	2.27	0.0001	202.94	202.74	0.9	0
585	WHAve7.1	WHAve7	WHAve7B	15.63	0.914	Circular Pipe	0.015	Reinforced Concrete Pipe	-0.51	0.0001	202.1	202.18	0	0
586	WHAve8.1	WHAve8	WHAve7	31.79	0.762	Circular Pipe	0.015	Reinforced Concrete Pipe	0.57	0.0001	202.28	202.1	0	0

APPENDIX I. INPUT PARAMETERS FOR EACH NODE

Table I-1: Information for Nodes 1 – 45

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
1	10St1	608457.347	4593898.724	205.58	206.44	3' X 1.5' P-50 Grate	1.62
2	10St2	608466.422	4593897.646	205.51	206.42	3' X 1.5' P-50 Grate	1.41
3	10St3	608378.791	4594092.34	209.66	212.4	3.1' X 2.1' Grate	--
4	10St5	608441.139	4594085.397	208.43	210.71	3.1' X 2.1' Grate	--
5	10St7	608457.08	4594021.537	207.74	208.81	3' X 1.5' P-50 Grate	--
6	10St8	608465.951	4594021.296	207.66	208.78	3' X 1.5' P-50 Grate	--
7	14st1	608935.004	4593530.407	201.98	203.01	Invert	--
8	14st10	608956.213	4593934.997	211.77	213.05	3' Curb Inlet	5.23
9	14St12	608956.167	4593944.784	211.83	213.19	3' Curb Inlet	4.29
10	14st13	608938.796	4594121.192	217.37	218.28	3' X 1.5' P-50 Grate	3.77
11	14st13B	608968.723	4594110.641	215.9	216.26	Invert	--
12	14st1B	608932.18	4593506.225	202	202.98	Invert	--
13	14St2	608956.21	4593532.759	202.45	203.13	Invert	--
14	14St2B	608957.598	4593507.915	202.23	202.85	Invert	--
15	14st3	608940.295	4593560.786	202.29	203.46	3' X 1.5' P-50 Grate	0.954
16	14St4	608948.629	4593560.515	202.82	203.43	3' X 1.5' P-50 Grate	0.833
17	14st5	608939.431	4593746.457	203.8	204.82	3' X 1.5' P-50 Grate	1.17
18	14st6	608947.664	4593746.242	204.17	204.85	3' X 1.5' P-50 Grate	1.15
19	14St8	608946.966	4593899.999	208.89	209.73	3' X 1.5' P-50 Grate	7.11
20	14St9	608938.849	4593899.586	208.92	209.73	3' X 1.5' P-50 Grate	7.38
21	1Pl3	607467.078	4594120.214	203.78	204.9	3' X 1.5' 45 Degree Tilt Grate	0.774
22	1Pl4	607474.311	4594120.691	203.87	204.93	3' X 1.5' 45 Degree Tilt Grate	0.323
23	2Pl1	607580.472	4594095.867	205.25	205.62	2' X 2' Grate	--
24	2Pl2	607588.538	4594096.148	205.34	205.69	2' X 2' Grate	--
25	3Pl1	607680.999	4594100.049	208.62	209.97	2' X 2' Grate	--
26	3Pl2	607689.19	4594100.242	209.02	210.06	2' X 2' Grate	--
27	3St1	607735.841	4593550.816	200.92	201.88	3' X 1.5' P-50 Grate	--
28	3St11	607796.227	4593732.655	202.59	203.58	Sealed	--
29	3St12	607807.157	4593732.259	202.85	203.3	3' X 1.5' P-50 Grate	1.1
30	3St2	607743.214	4593550.434	201	201.97	3' X 1.5' P-50 Grate	--
31	3St5	607735.776	4593614.138	201.02	202.09	3' X 1.5' P-50 Grate	1
32	3St7	607737.333	4593719.418	201.77	203.3	0.8' X 1' Grate	--
33	3St8	607745.152	4593718.318	201.9	203.21	8" Diameter Grate	--
34	3St9	607796.781	4593719.894	201.9	203.27	3' by 1.5' P-50 Grate	--
35	4St10	607891.352	4593248.14	200.09	201.11	2' X 3' P-50 Grate	0.86
36	4St11	607874.693	4593340.352	200.07	200.98	3' by 1.5' P-50 Grate	0.34
37	4St12	607885.451	4593340.246	200.48	200.93	3' by 1.5' P-50 Grate	1.9
38	4St13	607874.603	4593444.747	200.19	200.95	3' X 1.5' Grate	--
39	4St14	607886.465	4593444.913	200.4	200.96	3' X 1.5' Grate	--
40	4St16	607887.954	4593509.204	200.45	201.43	Sealed	--
41	4St18	607886.253	4593619.134	201.34	202.51	3' X 1.5' P-50 Grate	3
42	4St19	607877.88	4593618.964	201.68	202.54	3' X 1.5' P-50 Grate	3.2
43	4St21	607908.319	4593733.625	203.84	204.9	3' X 1.5' P-50 Grate	0.958
44	4St22	607915.172	4593734.609	203.76	204.98	3' X 1.5' P-50 Grate	1.6
45	4St23	607908.499	4593904.024	206.96	208.02	3' X 1.5' P-50 Grate	1.85

Table I-2: Information for Nodes 46 – 90

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
46	4St24	607915.821	4593905.366	207.36	208.05	3' X 1.5' P-50 Grate	1.85
47	4St3	607872.438	4593152.603	198.54	200.66	2' X 3' P-50 Grate	1.37
48	4St31	607908.914	4594062.59	210.59	211.65	3' X 1.5' P-50 Grate	2.27
49	4St32	607916.17	4594062.283	210.54	211.6	3' X 1.5' P-50 Grate	2.36
50	4St5	607873.381	4593209.533	199.27	201.05	3' X 1.5' P-50 Grate	--
51	4St7	607873.177	4593244.586	199.88	200.9	2' X 3' P-50 Grate	--
52	4St8	607885.277	4593244.737	199.96	201.01	2' X 3' P-50 Grate	3.4
53	5St1	608015.913	4593245.691	198.82	201.02	Sealed	--
54	5St13	608027.33	4593603.148	200.67	201.63	Sealed	--
55	5St14	608027.803	4593715.523	201.31	202.68	Sealed	--
56	5St15	608018.854	4593726.953	201.99	202.6	3' X 1.5' P-50 Grate	2.7
57	5St16	608027.803	4593725.658	201.28	202.5	3' X 1.5' P-50 Grate	1.61
58	5St18	608028.834	4593904.462	204.86	206.73	3' X 1.5' P-50 Grate	1.767
59	5St19	608020.289	4593904.481	206.31	206.92	3' X 1.5' P-50 Grate	1.5
60	5St20	608027.369	4594062.784	208.86	209.84	Sealed	--
61	5St22	608033.246	4594192.483	214	214.91	Sealed	--
62	5St24	608033.561	4594204.114	214.31	214.82	3' X 1.5' P-50 Grate	1.23
63	5St26	607775.144	4594302.058	209.57	211.24	9' Curb Inlet	--
64	5St27	607772.653	4594311.069	209.36	211.19	9' Curb Inlet	--
65	5St29	607740.793	4594326.478	207.67	209.2	4' Curb Inlet	--
66	5St3	608003.541	4593246.68	200.12	201.15	2' X 3' P-50 Grate	0.72
67	5St31	607884.937	4594345.995	209.19	210.87	4' Curb Inlet	--
68	5St32	607898.64	4594343.676	209	210.53	9' Curb Inlet	--
69	5St34	607931.475	4594369.259	207.49	209.85	9' Curb Inlet	--
70	5St35	607924.849	4594375.819	207.31	209.82	9' Curb Inlet	--
71	5St35B	607892.503	4594403.748	207.1	207.71	Invert	--
72	5St39	607948.636	4594400.973	207.42	210.16	4' Curb Inlet	--
73	5St4	608024.476	4593245.48	199.84	200.95	2' X 3' P-50 Grate	0.5
74	5St40	607965.632	4594407.961	207.7	210.38	9' Curb Inlet	--
75	5St41	608006.569	4594487.079	209.39	210.46	4' Curb Inlet	--
76	5St42	608019.211	4594489.481	209.14	210.36	9' Curb Inlet	--
77	5St44	608042.882	4594529.192	208.63	209.85	9' Curb Inlet	--
78	5St46	608047.977	4594533.502	208.5	209.8	4' Curb Inlet	--
79	5St48	608052.808	4594544.96	208.46	209.68	4' Curb Inlet	--
80	5St5	608017.078	4593276.626	198.86	200.85	2' X 3' P-50 Grate	0.92
81	5St50	608053.71	4594556.441	208.04	209.63	9' Curb Inlet	--
82	5St51	608044.873	4594559.112	207.93	209.6	9' Curb Inlet	--
83	5St51A	608004.338	4594572.447	207.5	208.96	Invert	--
84	5St52	608064.367	4594605.28	208.44	209.22	9' Curb Inlet	--
85	5St53	608056.584	4594625.428	208.35	209.11	4' X 2' Diameter Grate	--
86	5St54	608065.635	4594625.286	208.19	209.11	4' Curb Inlet	--
87	5St6	608024.296	4593276.5	199.71	200.79	2' X 3' P-50 Grate	0.6
88	5St7	608018.075	4593300.31	198.89	201.06	Sealed	--
89	5St9	608014.754	4593373.291	199.39	200.52	3' X 1.5' 45 Degree Tilt Grate	0.75
90	6St11	608128.1	4593245.365	199.43	200.32	3' X 1.5' P-50 Grate	3.5

Table I-3: Information for Nodes 91 – 135

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
91	6St12	608136.614	4593287.905	199.48	200.44	3' X 1.5' P-50 Grate	--
92	6St13	608119.627	4593285.731	199.65	200.39	3' X 1.5' 45 Degree Tilt Grate	--
93	6St14	608136.987	4593333.867	199.45	200.16	3' by 1.5' P-50 Grate	0.88
94	6St15	608128.266	4593334.937	199.68	200.24	3' by 1.5' P-50 Grate	0.88
95	6St17	608129.284	4593535.07	199.81	200.97	3' X 1.5' 45 Degree Tilt Grate	0.467
96	6St18	608137.438	4593535.439	200.27	201.03	1.8' X 2.7' grate	--
97	6St20	608137.152	4593650.461	200.34	201.51	3' X 1.5' P-50 Grate	1.8
98	6St22	608141	4593689.607	200.2	202.03	2' Diameter Grate	--
99	6St25	608128.601	4593727.267	201.54	202.25	3' X 1.5' P-50 Grate	1.86
100	6St26A	608147.187	4594479.666	217.31	217.95	Invert	--
101	6St26B	608146.925	4594492.423	216.98	217.59	Invert	--
102	6St28A	608144.606	4594536.728	215.81	216.42	Invert	--
103	6St28B	608145.135	4594544.955	215.49	216.12	Invert	--
104	6St3	608128.569	4593161.25	199.8	200.41	3' X 1.5' P-50 Grate	--
105	6St30A	608145.804	4594592.856	213.77	214.38	Invert	--
106	6St30B	608145.804	4594602.237	213.55	214.16	Invert	--
107	6St32A	608150.364	4594681.707	211.1	211.61	Invert	--
108	6St32B	608151.731	4594694.203	210.5	211.41	Invert	--
109	6St34	608140.259	4594690.569	211.22	212.23	Double 3' X 1.5' 45 Degree Tilt Grate	--
110	6St35	608131.314	4594690.992	211.19	212.25	Double 3' X 1.5' 45 Degree Tilt Grate	--
111	6St35B	608125.094	4594690.753	210.48	210.79	Invert	--
112	6St36A	608146.838	4594695.723	210.53	211.85	Invert	--
113	6St36B	608128.864	4594694.736	210.15	211.47	Invert	--
114	6St3B	608108.199	4593152.8	200.13	200.72	3' X 1.5' Grate	--
115	6St4	608136.569	4593246.863	199.5	200.06	3' X 1.5' 45 Degree Tilt Grate	0.312
116	6St9	608120.324	4593240.108	199.47	200.15	2' X 3' P-50 Grate	0.82
117	7St10	608342.662	4593279.12	198.87	200.29	1.5' Diameter Grate	--
118	7St11	608215.071	4593293.833	199.58	199.87	3' X 1.5' 45 Degree Tilt Grate	0.42
119	7St12	608348.366	4593278.981	197.81	200.31	Sealed	--
120	7St13	608234.378	4593301.66	199.45	200.02	3' X 1.5' P-50 Grate	0.53
121	7St16	608242.564	4593301.912	199.6	200.08	3' X 1.5' P-50 Grate	0.53
122	7St17	608233.477	4593391.707	199.04	200.44	Sealed	--
123	7St18	608354.429	4593392.239	198.17	200.34	Sealed	--
124	7St19	608233.367	4593434.18	199.35	200.14	3' X 1.5' P-50 Grate	0.707
125	7St2	608347.972	4593249.591	197.84	200.23	Sealed	--
126	7St20	608241.583	4593433.621	199.4	200.16	3' X 1.5' P-50 Grate	0.707
127	7St21	608251.892	4593893.731	205.91	206.46	3' by 1.5' P-50 Grate	2.36
128	7St22	608273.059	4593893.469	205.76	206.22	3' X 1.5' P-50 Grate	2.32
129	7St23	608247.607	4594036.096	209.99	211.36	Sealed	--
130	7St25.1	608257.611	4594034.78	210.09	210.9	3' X 1.5' P-50 Grate	3.17
131	7St26	608266.673	4594034.667	210.44	210.9	3' X 1.5' P-50 Grate	3.5
132	7St29	608236.346	4594485.511	222.21	223.66	4' Curb Inlet	--
133	7St3	608234.19	4593247.821	199.4	199.99	3' X 1.5' Grate	--
134	7St31	608220.989	4594485.222	218.86	221.76	Sealed	--
135	7St33	608198.649	4594479.647	217.67	219.02	2' Diameter Grate	--

Table I-4: Information for Nodes 136 – 180

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
136	7St4	608243.406	4593246.433	199.27	199.86	3' X 1.5' Grate	--
137	7St6	608303.97	4593249.508	198.32	199.62	2' Diameter Grate	--
138	8St2	608349.411	4593491.792	198.54	200.37	1.5' Diameter Grate	--
139	8St4	608349.405	4593634.081	201.46	202.37	3' X 1.5' P-50 Grate	1.14
140	8St6	608344.859	4593643.043	201.4	202.36	3' X 1.5' P-50 Grate	2.2
141	9St11	608421.022	4594261.122	220.48	221.39	3' X 2' P-50 Grate	2
142	9St14	608430.002	4594263.587	220.18	221.18	3' X 2' P-50 Grate	4.27
143	9st2	608438.06	4593203.993	199.14	199.85	3' X 1.5' P-50 Grate	0.15
144	9St4	608443.321	4593291.401	199.52	199.83	Invert	--
145	9St6	608456.248	4593291.694	198.91	200.41	Sealed	--
146	9St7	608439.865	4593554.998	200.61	201.8	3' X 1.5' P-50 Grate	1.8
147	9St9	608430.96	4593554.922	200.76	201.77	3' X 1.5' P-50 Grate	0.55
148	AAve1	607663.202	4593069.875	200.34	200.73	3' X 1.5' P-50 Grate	0.36
149	AAve10	608168.082	4593069.314	198.92	199.3	3' X 1.5' 45 Degree Tilt Grate	0.833
150	AAve11	608135.153	4593057.367	198.49	199.71	Double 2.4' X 3.6' Grate	--
151	AAve13	608169.213	4593061.851	198.69	199.28	3' X 1.5' 45 Degree Tilt Grate	0.343
152	AAve15	608346.711	4593059.042	197.34	199.5	3' X 1.5' 45 Degree Tilt Grate	0.55
153	AAve16	608346.614	4593066.303	197.19	199.34	3' X 1.5' 45 Degree Tilt Grate	0.35
154	AAve17	608347.384	4593011.44	196.87	200.15	Sealed	--
155	AAve18	608345.092	4593090.922	197.99	199.46	2' Diameter Grate	--
156	AAve2	607663.493	4593076.974	200.08	200.82	3' X 1.5' P-50 Grate	0.36
157	AAve21	608761.138	4593053.236	199.12	199.79	Invert	--
158	AAve22	608761.882	4593072.624	199.46	200	Invert	--
159	AAve24	608773.946	4593096.866	199.6	200.21	Invert	--
160	AAve26	608773.945	4593103.051	199.67	200.28	Invert	--
161	AAve3	607856.827	4593068.247	199.71	200.1	3' X 1.5' P-50 Grate	1
162	AAve4	607858.047	4593075.3	199.75	200.04	3' X 1.5' P-50 Grate	1.56
163	AAve5	607993.879	4593065.443	199.23	199.69	3' X 1.5' P-50 Grate	1
164	AAve6	607994.065	4593072.808	199.2	199.62	3' X 1.5' P-50 Grate	1.8
165	AAve7	608076.967	4593063.761	198.84	199.42	3' X 1.5' P-50 Grate	0.55
166	AAve8	608071.405	4593071.004	199.08	199.51	3' X 1.5' P-50 Grate	1.05
167	AAve9	608130.619	4593061.822	198.61	199.47	1.8' X 2.7' grate	--
168	Apl1	607764.07	4593139.205	198.39	200.66	3' X 1.5' P-50 Grate	0.6
169	Apl10	607886.469	4593145.853	199.75	200.69	2' X 3' P-50 Grate	1
170	Apl3	607807.762	4593138.704	198.44	200.56	3' X 1.5' P-50 Grate	0.84
171	Apl5	607851.652	4593138.813	198.44	200.62	3' X 1.5' P-50 Grate	0.6
172	Apl7	607874.525	4593139.862	198.52	200.89	Sealed	--
173	Apl9	607885.045	4593138.294	199.66	200.66	2' X 3' P-50 Grate	0.76
174	BAve1	607446.238	4593198.553	200.41	201.31	3' X 1.5' P-50 Grate	0.06
175	BAve10	607894.782	4593199.644	199.88	200.96	2' X 3' P-50 Grate	0.57
176	BAve11	607894.461	4593191.789	198.61	200.94	2' X 3' P-50 Grate	0.91
177	BAve13	607922.334	4593191.378	198.64	200.98	2' X 3' P-50 Grate	0.5
178	BAve14	607963.157	4593198.495	200.22	201.28	2' X 3' P-50 Grate	0.91
179	BAve15	607963.07	4593190.287	198.69	201.24	2' X 3' P-50 Grate	0.5
180	BAve17	608014.65	4593188.921	198.75	201.6	Sealed	--

Table I-5: Information for Nodes 181 – 225

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
181	BAve19	608100.003	4593187.928	199.41	200.49	2' X 3' P-50 Grate	0.5
182	BAve2	607446.711	4593210.591	200.42	201.36	3' X 1.5' P-50 Grate	0.5
183	BAve20	608100.273	4593196.109	199.47	200.48	2' X 3' P-50 Grate	0.5
184	BAve21	608232.354	4593173.885	199.05	199.7	2' Diameter Grate	2.2
185	BAve23	608346.049	4593173.928	197.91	200.05	2' Diameter Grate	--
186	BAve3	607680.835	4593193.74	199.8	201.11	3' X 1.5' P-50 Grate	1
187	BAve4	607681.307	4593206.235	200.01	201.2	3' X 1.5' P-50 Grate	0.34
188	BAve6	607737.554	4593210.638	200.01	201.23	3' X 2' Grate	--
189	BAve7	607862.613	4593189.928	199.81	200.83	3' X 1.5' 45 Degree Tilt Grate	0.5
190	BAve8	607863.152	4593202.484	199.92	200.79	3' X 1.5' 45 Degree Tilt Grate	0.5
191	BAve9	607874.857	4593193.644	198.59	201.07	Sealed	--
192	CAve1	607311.072	4593307.077	201.2	201.45	8" Diameter Grate	--
193	CAve10	607644.459	4593303.587	201.26	201.87	3' X 1.5' P-50 Grate	1.5
194	CAve14	607715.65	4593302.005	200.59	201.53	3' by 1.5' P-50 Grate	1.36
195	CAve15	607715.487	4593293.351	201.07	201.61	3' by 1.5' P-50 Grate	1.25
196	CAve17	607848.883	4593291.26	200.58	201.19	3' X 1.5' 45 Degree Tilt Grate	2.6
197	CAve18	607849.272	4593299.774	200.75	201.12	3' X 1.5' 45 Degree Tilt Grate	2.6
198	CAve19	607978.853	4593289.224	199.89	200.88	2' X 3' P-50 Grate	0.24
199	CAve2	607343.289	4593311.919	201.93	202.4	2' Diameter Grate	0.5
200	CAve20	607979.511	4593297.907	199.73	200.85	2' X 3' P-50 Grate	0.24
201	CAve24	608072.346	4593298.593	199.35	200.67	3' X 1.5' 45 Degree Tilt Grate	0.55
202	CAve25	608210.77	4593278.423	199.59	200	1.5' Diameter Grate	--
203	CAve27	608214.805	4593285.018	199.46	199.89	3' X 1.5' 45 Degree Tilt Grate	0.56
204	CAve29	608257.283	4593284.84	199.08	199.87	3' X 1.5' P-50 Grate	0.95
205	CAve30	608257.287	4593292.869	199.09	199.9	3' X 1.5' P-50 Grate	0.95
206	CAve32	608304.43	4593293.115	198.34	200.11	3' X 1.5' P-50 Grate	0.64
207	CAve34	608349.348	4593292.749	197.8	200.19	Sealed	--
208	CAve36	608402.415	4593290.613	198.71	199.91	3' X 1.5' P-50 Grate	0.26
209	CAve37	608402.091	4593282.145	198.78	199.91	3' X 1.5' P-50 Grate	2
210	CAve39	608391.984	4593279.019	198.99	199.85	1.5' Diameter Grate	--
211	CAve4	607456.715	4593307.299	200.79	201.63	3' X 1.5' P-50 Grate	0.85
212	CAve5	607456.628	4593299.287	200.79	201.68	3' X 1.5' P-50 Grate	0.97
213	CAve7	607543.452	4593297.273	201.25	201.84	3' by 1.5' P-50 Grate	0.12
214	CAve8	607544.966	4593305.576	201.19	201.7	3' by 1.5' P-50 Grate	1.3
215	CAve9	607643.507	4593295.446	201.18	201.94	3' X 1.5' P-50 Grate	1.05
216	Cen1	608547.564	4594167.582	210.04	211.5	Invert	--
217	Cen10	608540.763	4593578.044	200.44	203.56	Open	--
218	Cen11	608541.422	4593519.325	199.55	202.48	Open	--
219	Cen12	608541.555	4593500.02	197.87	201.93	Open	--
220	Cen13	608542.505	4593403.518	198.38	202.44	Open	--
221	Cen14	608542.155	4593387.225	198.3	201.32	Open	--
222	Cen15	608542.853	4593293.399	198.1	201	Open	--
223	Cen16	608544.556	4593065.04	197.61	201.1	Open	--
224	Cen17	608544.805	4593056.003	197.52	199.66	Open	--
225	Cen18	608549.477	4592909.448	197.24	200	Open	--

Table I-6: Information for Nodes 226 – 270

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
226	Cen19	608549.02	4592746.856	196.93	200	Open	--
227	Cen2	608544.601	4594146.474	209.41	213.54	Open	--
228	Cen20	608554.669	4592457.335	196.37	200	Open	--
229	Cen21	608556.039	4592292.268	196.05	198.18	Open	--
230	Cen22	608557.365	4592276.838	195.84	199.3	Open	--
231	Cen23	608606.806	4591884.6	195.42	200	Open	--
232	Cen24	608627.737	4591831.357	195.38	200	Open	--
233	Cen3	608540.871	4594021.671	207.32	212	Open	--
234	Cen4	608541.919	4593895.142	205.23	208.08	Open	--
235	Cen5	608541.85	4593870.436	204.38	205.96	Default	--
236	Cen6a	608541.811	4593837.983	203.71	205.47	Sealed	--
237	Cen7	608541.452	4593755.212	202.08	204.11	Default	--
238	Cen8	608541.27	4593668.753	201.42	203.96	3' X 1.5' P-50 Grate	--
239	Cen9	608540.91	4593594.946	200.93	204.19	Open	--
240	Church1	608198.246	4594279.111	216.59	219.9	6" Diameter Grate	--
241	Church2	608157.921	4594297.675	217.05	221.31	6" Diameter Grate	--
242	DAve1	607404.825	4593361.912	201.67	202.11	0.8' X 1' Grate	--
243	DAve10	607485.704	4593366.387	201.14	202.15	1' Diameter Grate	--
244	DAve11	607494.666	4593359.826	201.51	201.95	0.8' X 1' Grate	--
245	DAve12	607509.923	4593366.278	200.9	202.15	1' Diameter Grate	--
246	DAve13	607517.44	4593359.335	200.9	201.81	0.8' X 1' Grate	--
247	DAve15	607566.895	4593358.771	200.41	202.08	0.8' X 1' Grate	--
248	DAve16	607569.818	4593365.931	200.3	202.16	1' Diameter Grate	--
249	DAve17	607607.483	4593357.844	200	202.19	0.8' X 1' Grate	--
250	DAve21	607808.33	4593392.804	200.59	201.2	3' X 1.5' P-50 Grate	0.9
251	DAve24	607808.439	4593401.127	200.61	201.13	3' X 1.5' P-50 Grate	1.3
252	DAve25	608011.001	4593392.333	199.53	200.59	3' X 1.5' P-50 Grate	1.35
253	DAve26	608010.403	4593400.658	199.74	200.6	3' X 1.5' P-50 Grate	1.55
254	DAve27	608089.054	4593392.162	199.54	200.34	3' X 1.5' P-50 Grate	1.3
255	DAve28	608088.89	4593400.59	199.56	200.39	3' X 1.5' P-50 Grate	1.2
256	DAve3	607423.603	4593361.53	201.62	202.05	0.8' X 1' Grate	--
257	DAve32	608126.276	4593400.592	199.66	200.37	3' by 1.5' P-50 Grate	0.6
258	DAve34	608137.236	4593402.59	199.59	200.35	3' by 1.5' P-50 Grate	1.4
259	DAve37	608165.125	4593392.235	198.99	200.19	3' X 1.5' P-50 Grate	3
260	DAve38	608165.258	4593400.553	199.48	200.17	3' X 1.5' P-50 Grate	3
261	DAve41	608347.712	4593392.571	199.12	200.01	3' X 1.5' P-50 Grate	1.2
262	DAve42	608347.52	4593400.686	199.46	199.99	3' X 1.5' P-50 Grate	1.2
263	DAve5	607448.045	4593360.826	201.64	202.09	0.8' X 1' Grate	--
264	DAve6	607450.235	4593367.441	201.31	202.22	1' Diameter Grate	--
265	DAve7	607472.85	4593360.221	201.56	202.16	0.8' X 1' Grate	--
266	DAve8	607460.787	4593366.839	201.18	202.17	1' Diameter Grate	--
267	Dit1	607736.688	4594339.647	207.54	208.63	Sealed	--
268	Dit10	607994.33	4594553.925	206.05	207.01	8" Diameter Grate	--
269	Dit2	607757.805	4594348.099	207.42	207.78	Invert	--
270	Dit3	607836.978	4594370.902	206.47	207.28	8" Diameter Grate	--

Table I-7: Information for Nodes 271 – 315

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
271	Dit4	607902.748	4594420.5	206.46	207.12	8" Diameter Grate	--
272	Dit5	607924.714	4594306.238	212.3	213.42	3.1' X 2.1' Grate	--
273	Dit6	607966.252	4594340.601	211.73	213.41	3.1' X 2.1' Grate	--
274	Dit7	607993.162	4594372.746	210.97	213.41	2' X 2' Grate	--
275	Dit8	608000.682	4594384.333	210.79	215.4	Sealed	--
276	Dit9	607950.827	4594485.48	206.29	207.3	8" Diameter Grate	--
277	E1252A	608587.042	4592293.815	197.98	198.37	Invert	--
278	E1253A	608710.91	4592277.638	198.14	198.6	Invert	--
279	E1253B	608703.351	4592277.766	198.1	199.5	Invert	--
280	E1254A	608776.125	4592293.553	198.65	199.11	Invert	--
281	E1254B	608766.959	4592293.241	198.6	199.69	Invert	--
282	Eave1.1	607435.024	4593482.36	202.13	203.13	Invert	--
283	EAve10a	607690.757	4593515.911	200.6	201.67	2.5' X 1.5' Diameter Grate	--
284	EAve13a	607865.094	4593495.781	200.05	201.15	4' Curb Inlet	1.4
285	EAve14a	607865.17	4593509.096	200.03	201.12	4' Curb Inlet	1.4
286	EAve17	607942.161	4593495.761	200.01	201	4' Curb Inlet	0.55
287	EAve18A	607942.75	4593509.082	200.04	201.09	4' Curb Inlet	0.55
288	EAve1B	607444.272	4593482.85	202.06	203.06	Invert	--
289	EAve20a	608027.272	4593509.15	200.13	201.06	Sealed	--
290	EAve21	608035.54	4593495.786	199.48	200.85	4' Curb Inlet	0.3
291	EAve22a	608035.9	4593509.138	199.77	200.84	4' Curb Inlet	0.17
292	EAve24	608128.534	4593510.555	199.68	201.27	Sealed	--
293	EAve26	608137.738	4593510.631	199.64	201.28	Sealed	--
294	EAve27	608148.022	4593497.198	199.56	201.15	4' Curb Inlet	0.22
295	EAve28	608147.885	4593510.761	199.61	201.17	4' Curb Inlet	0.34
296	EAve30	608146.57	4593524.43	200.05	201.11	2' Diameter Grate	--
297	EAve32	608156.817	4593518.608	199.7	200.92	2.3' Diameter Grate	--
298	EAve34	608182.366	4593538.472	200.88	201.19	2' Diameter Grate	--
299	EAve36	608187.692	4593521.887	199.7	203.23	Open	--
300	EAve38	608232.02	4593523.457	199.56	201.72	Open	--
301	EAve39	608251.327	4593499.294	200.36	201.62	4' Curb Inlet	0.9
302	EAve3A	607463.843	4593483.227	201.99	202.99	Invert	--
303	EAve3B	607482.639	4593483.295	201.96	202.96	Invert	--
304	EAve40	608254.561	4593512.784	200.05	201.62	4' Curb Inlet	0.9
305	EAve42	608247.807	4593523.829	199.59	202.14	Open	--
306	EAve44	608329.617	4593526.515	199.34	201.89	Open	--
307	EAve45	608350.595	4593501.303	199.83	201.2	4' Curb Inlet	0.55
308	EAve46	608354.41	4593513.186	200.69	202.04	4' Curb Inlet	0.55
309	EAve48	608345.949	4593527.107	199.27	202.93	Open	--
310	EAve50	608426.507	4593529.767	199.25	202.9	Open	--
311	EAve52	608444.169	4593529.854	199.24	203.25	Open	--
312	EAve54	608535.69	4593536.73	201.2	202.42	3' X 1.5' P-50 Grate	1.4
313	EAve56	608526.653	4593536.484	200.83	202.35	3' X 1.5' P-50 Grate	--
314	EAve58a	608516.254	4593522.799	199.077	202.6	Open	--
315	EAve59	608565.501	4593495.396	201.59	202.05	Invert	--

Table I-8: Information for Nodes 316 – 360

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
316	EAve5A	607507.446	4593483.772	201.71	202.71	Invert	--
317	EAve60A	608585.007	4593526.099	201.77	202.23	Invert	--
318	EAve60B	608593.633	4593525.764	201.72	202.59	Invert	--
319	EAve62A	608630.749	4593526.254	201.84	202.7	Invert	--
320	EAve62B	608646.084	4593526.759	201.79	202.86	Invert	--
321	EAve64	608664.768	4593524.665	201.51	202.58	Invert	--
322	EAve65	608664.173	4593499.776	201.1	201.84	Invert	--
323	EAve67A	608721.008	4593500.249	201.2	201.66	Invert	--
324	EAve67B	608732.141	4593500.27	201.26	201.72	Invert	--
325	EAve68A	608746.671	4593528.748	201.97	202.51	Invert	--
326	EAve68B	608761.807	4593528.998	202	202.46	Invert	--
327	EAve69A	608774.468	4593497.982	202.01	202.47	Invert	--
328	EAve69B	608792.067	4593497.948	201.95	202.41	Invert	--
329	EAve6A	607524.259	4593512.614	202.01	203.01	Invert	--
330	EAve6B	607542.828	4593513.229	201.84	202.84	Invert	--
331	EAve7	607543.508	4593484.083	201.54	202.64	3' X 1.5' P-50 Grate	--
332	EAve70A	608877.288	4593531.877	202.3	202.76	Invert	--
333	EAve70B	608889.043	4593532.111	202.22	202.68	Invert	--
334	EAve72A	609073.838	4593555.149	203.39	203.85	Invert	--
335	EAve72B	609095.934	4593562.078	203.51	203.97	Invert	--
336	EAve74A	609224.573	4593611.907	203.33	204.33	Invert	--
337	EAve74B	609235.886	4593615.655	203.58	204.58	Invert	--
338	EAve76A	609559.455	4593731.591	220.03	220.73	Invert	--
339	EAve76B	609571.003	4593736.304	220.48	221.23	Invert	--
340	EAve7B	607560.694	4593484.672	201.74	202.74	Invert	--
341	EAve9A	607565.701	4593484.691	201.64	202.64	Invert	--
342	EAve9B	607580.046	4593484.836	201.51	202.51	Invert	--
343	EPl1	608646.656	4593594.252	201.41	202.25	3' X 1.5' P-50 Grate	0.215
344	EPl2	608633.735	4593603.59	201.74	202.2	3' X 1.5' P-50 Grate	1.3
345	Est1A	609301.477	4594478.914	211.56	212.48	Invert	--
346	Est1B	609306.748	4594470.664	211.57	212.64	Invert	--
347	Est2A	609212.052	4593601.129	202.4	206.13	Invert	--
348	Est2B	609218.378	4593574.98	202.3	205.87	Invert	--
349	Est3A	609223.861	4593089.957	199.56	201.77	Invert	--
350	Est3B	609224.283	4593071.821	199.45	202.35	Invert	--
351	Est4	609354.989	4591975.417	196.12	198.41	Invert	--
352	Est5	609355.629	4591951.116	196.09	198.38	Open	--
353	Est7	609395.214	4591654.325	194.45	200	Open	--
354	Est8	609423.352	4591597.345	194.11	200	Open	--
355	FAve11	608744.088	4593699.956	201.68	202.8	3' X 1.5' P-50 Grate	0.77
356	FAve2	607743.724	4593614.363	201.18	202	3' X 1.5' P-50 Grate	0.8
357	FAve4	607794.642	4593612.573	201.38	201.99	3' X 1.5' P-50 Grate	1.9
358	FAve5	607795.612	4593604.32	201.41	201.95	3' X 1.5' P-50 Grate	1.9
359	FAve6	607973.565	4593613.049	201.75	202.41	3' X 1.5' P-50 Grate	0.95
360	FAve7	607977.4	4593604.157	200.95	201.86	3' X 1.5' P-50 Grate	0.95

Table I-9: Information for Nodes 361 – 405

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
361	FAve8	608746.027	4593708.22	201.78	202.74	3' X 1.5' P-50 Grate	0.77
362	FAve9	608762.579	4593699.975	201.68	202.75	3' X 1.5' P-50 Grate	0.8
363	FPl1	607635.274	4593604.304	200.36	202.19	3' X 2' Grate	1.1
364	FPl10	607640.35	4593777.606	201.87	203.3	4' Curb Inlet	1.1
365	FPl11	607575.85	4593670.125	201.35	202.66	4' Curb Inlet	2.1
366	FPl12	607584.328	4593673.722	201.42	202.69	4' Curb Inlet	1.1
367	FPl13	607528.689	4593781.745	202.22	203.4	4' Curb Inlet	0.54
368	FPl14	607537.736	4593783.263	202.39	203.32	4' Curb Inlet	0.85
369	FPl4	607637.326	4593614.218	200.53	202.18	4' Curb Inlet	0.71
370	FPl5	607627.027	4593627.634	200.69	202.29	4' Curb Inlet	0.964
371	FPl6	607619.401	4593632.878	200.62	202.27	4' Curb Inlet	0.964
372	FPl7	607645.94	4593656.686	201.22	202.5	4' Curb Inlet	0.73
373	FPl8	607639.512	4593665.432	201.31	202.52	4' Curb Inlet	2.2
374	FPl9	607649.652	4593773.202	201.93	203.26	4' Curb Inlet	0.52
375	GAve2	608078.267	4593719.061	201.76	202.38	3' X 1.5' P-50 Grate	0.54
376	GAve3	608078.245	4593711.264	201.72	202.33	3' X 1.5' P-50 Grate	1.67
377	HAve1	607797.541	4593909.333	205.85	206.76	3' X 1.5' P-50 Grate	2.91
378	HAve10	608316.973	4593896.752	205.57	205.93	1.5' Diameter Grate	--
379	HAve11	608392.662	4593883.982	205.3	206.01	3' X 1.5' P-50 Grate	0.392
380	HAve12	608392.307	4593892.624	205.43	206.04	3' by 1.5' P-50 Grate	0.127
381	HAve15	608467.029	4593876.318	204.82	206.35	Sealed	--
382	HAve17	608559.499	4593882.209	205.64	206.46	3' X 1.5' P-50 Grate	0.393
383	HAve18	608559.15	4593891.289	205.89	206.5	3' X 1.5' P-50 Grate	0.429
384	HAve19	608604.488	4593883.182	205.32	206.44	3' X 1.5' P-50 Grate	0.63
385	HAve2	607806.586	4593909.901	206.16	206.77	3' X 1.5' P-50 Grate	2.91
386	HAve20	608599.725	4593891.328	205.74	206.43	3' X 1.5' P-50 Grate	1.56
387	HAve21	608690.032	4593883.429	205.08	206.05	3' X 1.5' P-50 Grate	0.461
388	HAve22	608690.632	4593891.486	205.07	206.18	3' X 1.5' P-50 Grate	0.786
389	HAve24	608706.362	4593891.452	205.29	206.2	3' X 1.5' P-50 Grate	0.454
390	HAve26	608801.205	4593895.071	206.51	207.31	3' X 1.5' P-50 Grate	7.82
391	HAve28	608814.009	4593891.323	206.05	207.22	3' X 1.5' P-50 Grate	5.77
392	HAve3	608263.06	4593878.917	205.51	206.25	Sealed	--
393	HAve5	608330.246	4593875.755	205.44	206.14	Sealed	--
394	HAve7	608330.256	4593884.073	205.29	205.98	3' X 1.5' P-50 Grate	0.291
395	HAve8	608331.185	4593893.088	205.36	205.97	3' X 1.5' P-50 Grate	0.291
396	HAve9	608393.163	4593875.122	205.15	206.28	Sealed	--
397	HHoutlet	607033.875	4593908.493	201.42	201.73	Invert	--
398	HW110A	607354.533	4592366.572	198.2	199.34	Invert	--
399	HW110B	607354.125	4592406.67	198.25	199.2	Invert	--
400	HW112A	607343.149	4592702.228	199.21	199.82	Invert	--
401	HW112B	607342.874	4592721.303	199.21	199.85	Invert	--
402	HW114A	607340.093	4592890.102	199.68	200.38	Invert	--
403	HW114B	607339.433	4592903.101	199.88	200.58	Invert	--
404	HW116A	607338.522	4593024.309	201.84	202.3	Invert	--
405	HW116B	607338.28	4593035.363	201.99	202.45	Invert	--

Table I-10: Information for Nodes 406 – 450

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
406	HW117A	607311.908	4593169.701	202.35	202.71	Invert	--
407	HW117B	607311.18	4593189.933	202.47	202.83	Invert	--
408	HW119A	607310.896	4593199.347	202.24	202.73	Invert	--
409	HW119B	607310.377	4593217.26	202.12	202.54	Invert	--
410	HW12A	607356.266	4591911.875	197.25	198.27	Invert	--
411	HW12B	607356.28	4591925.906	197.35	198.37	Invert	--
412	HW14A	607357.09	4592099.566	197.39	198.38	Invert	--
413	HW14B	607357.085	4592112.993	197.48	198.47	Invert	--
414	HW16A	607355.137	4592306.525	198.14	199.03	Invert	--
415	HW16B	607354.907	4592330.676	198.15	199.07	Invert	--
416	HW18B	607391.34	4592377.489	199.22	199.63	Invert	--
417	HW20A	607320.617	4596386.992	228.79	230.26	Invert	--
418	HW20B	607331.984	4596386.194	227.65	229.51	Sealed	--
419	HW20C	607342.065	4596385.486	226.58	228.45	Sealed	--
420	HW20D	607352.158	4596384.777	225.92	227.39	Invert	--
421	HW21A	607321.477	4596404.983	229.15	230.98	Invert	--
422	HW21B	607342.746	4596405.021	228.97	230.8	Invert	--
423	JAve10	608137.649	4594207.015	216.08	216.61	Double 3' X 1.5' 45 Degree Tilt Grate	4
424	JAve14	608214.244	4594194.313	215.72	216.33	3' X 1.5' P-50 Grate	4.77
425	JAve15	608233.052	4594180.697	215.29	216.05	3' X 1.5' Grate	--
426	JAve16	608248.509	4594190.875	215.42	216.18	3.5' X 2.1' Grate	--
427	JAve18	608257.071	4594192.111	215.27	216.49	3' by 1.5' P-50 Grate	1.731
428	JAve19	608252	4594174.938	214.62	216.26	Sealed	--
429	JAve2	607466.326	4594227.092	204.42	205.33	3' X 1.5' P-50 Grate	0.621
430	JAve22	608266.091	4594191.458	215.25	216.32	3' X 1.5' P-50 Grate	1.731
431	JAve24	608345.083	4594187.708	217.17	218.24	3' X 1.5' P-50 Grate	2.325
432	JAve26	608354.1	4594187.146	217.59	218.2	3' X 1.5' P-50 Grate	1.96
433	JAve28	608482.283	4594175.139	212.62	213.54	3' by 1.5' P-50 Grate	4.95
434	JAve3	607602.394	4594217.007	205.72	206.65	3' X 1.5' P-50 Grate	--
435	JAve30	608491.25	4594174.031	212.56	213.48	3' by 1.5' P-50 Grate	4.71
436	JAve34	608679.842	4594153.376	214.18	216.37	9' Curb Inlet	3.54
437	JAve36	608689.889	4594153.335	215.08	216.63	9' Curb Inlet	3.54
438	JAve38	608782.382	4594146.635	221.8	223.94	4' Curb Inlet	1.82
439	JAve4	607601.379	4594225.832	205.81	206.57	3' X 1.5' P-50 Grate	0.321
440	JAve40	608790.959	4594145.852	222.25	224.08	4' Curb Inlet	1.82
441	JAve5	608127.685	4594186.909	215.28	215.97	Sealed	--
442	JAve6	608128.531	4594208.009	216.14	216.59	Double 3' X 1.5' 45 Degree Tilt Grate	0.414
443	JAve7	608146.748	4594186.857	215.54	216.05	3' X 1.5' P-50 Grate	2.33
444	JAve8	608147.053	4594195.874	215.76	216.07	3' X 1.5' P-50 Grate	2.3
445	Jpl1	609068.186	4594015.303	211.27	212.17	9' Curb Inlet	1.06
446	Jpl2	609076.311	4594014.377	210.93	212.19	9' Curb Inlet	1.06
447	JPl2B	609158.866	4593993.415	206.56	210.25	Invert	--
448	JW1A	607800.247	4596326.833	216.05	217.33	Invert	--
449	JW1B	607811.198	4596309.464	215.93	217.21	Invert	--
450	JW2A	608170.6	4596325.27	215.98	218.18	Invert	--

Table I-11: Information for Nodes 451 – 495

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
451	JW2B	608171.104	4596307.223	215.53	217.73	Invert	--
452	KAve1	608497.125	4594261.698	215.59	216.81	3' X 1.5' P-50 Grate	--
453	KAve10	608505.642	4594415.798	220.8	221.71	3' X 1.5' P-50 Grate	--
454	KAve11	608496.681	4594415.448	220.98	221.75	3' X 1.5' P-50 Grate	--
455	KAve2	608506.143	4594262.241	215.12	216.8	3' X 1.5' P-50 Grate	4.8
456	KAve4	608517.484	4594260.653	214.92	216.39	Sealed	--
457	KAve8	608516.606	4594415.932	220.69	221.99	Sealed	--
458	Kct1	608039.607	4594364.464	216.2	220.77	9' Curb Inlet	--
459	MAve1	608075.399	4594495.017	212.34	213.56	9' Curb Inlet	--
460	MAve2	608084.637	4594494.943	212.13	213.66	4' Curb Inlet	--
461	MAve3	608432.465	4594503.959	225.73	226.34	3' X 1.5' P-50 Grate	--
462	MAve4	608440.35	4594499.623	225.52	226.28	3' X 1.5' P-50 Grate	--
463	Mercy1	607726.11	4593550.903	201.25	202.38	1' X 2' Grate	--
464	Mercy2	607726.718	4593543.711	201.61	202.14	1' X 2' Grate	--
465	Mercy3	607726.85	4593562.481	201.74	202.22	1' X 2' Grate	--
466	Mercy4	607707.318	4593562.964	201.75	202.21	1' X 2' Grate	--
467	NAve1	608010.846	4594633.444	206.97	208.1	Invert	--
468	NAve3	608008.564	4594646.284	207.11	208.63	4' Curb Inlet	--
469	NAve4	608008.423	4594658.479	207.42	208.64	4' Curb Inlet	--
470	NAve5	608077.479	4594645.768	207.57	210.32	4' Curb Inlet	--
471	NAve6	608078.155	4594657.922	207.72	210.3	4' Curb Inlet	--
472	NMap1A	608131.768	4595398.442	212.04	213.04	Invert	--
473	NMap1B	608115.888	4595397.791	211.23	212.23	Invert	--
474	NMap2A	608124.796	4595693.685	212.43	213.73	Invert	--
475	NMap2B	608111.485	4595691.754	212.1	213.4	Invert	--
476	NMap3A	608117.839	4596019.657	217.05	217.87	Invert	--
477	NMap3B	608103.887	4596013.542	216.67	217.49	Invert	--
478	NMap4A	608111.748	4596241.783	214.51	216.04	Invert	--
479	NMap4B	608099.096	4596223.306	214.42	215.95	Invert	--
480	NNut1A	608930.546	4594985.561	223.71	224.73	Invert	--
481	NNut1B	608943.347	4594984.207	223.34	224.36	Invert	--
482	NNut1C	608950.237	4594982.846	221.88	222.65	Invert	--
483	NNut2A	608946.129	4595003.153	223.15	223.77	Invert	--
484	NNut2B	608944.154	4595015.401	223.48	224.09	Invert	--
485	NNut3A	608927.673	4595038.589	224.18	224.97	Invert	--
486	NNut3B	608927.414	4595047.702	224.27	225.06	Invert	--
487	NNut5A	608924.601	4595098.578	225.01	225.8	Invert	--
488	NNut5B	608925.288	4595086.448	224.94	225.73	Invert	--
489	NNut6A	608915.907	4595914.375	219.9	221.48	Invert	--
490	NNut6B	608905.404	4595913.965	219.82	221.4	Invert	--
491	Pk1	608076.634	4593307.304	199.37	200.63	2' X 3' P-50 Grate	--
492	Pk2	608069.234	4593307.062	199.82	200.8	3' X 1.5' 45 Degree Tilt Grate	4.25
493	Pk4	608076.772	4593343.034	199.44	200.67	2' X 3' P-50 Grate	2
494	Pk5	608051.629	4593343.838	199.73	200.77	2' X 3' P-50 Grate	2
495	Pk7	608083.731	4593369.388	199.5	200.49	2' X 3' P-50 Grate	--

Table I-12: Information for Nodes 496 – 540

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
496	Pond1A	607803.867	4595245.626	216.15	217.15	Invert	--
497	Pond1B	607824.939	4595238.849	214.03	215.03	Invert	--
498	Prie1	608448.928	4593859.76	204.37	204.98	3' X 1.5' P-50 Grate	--
499	Prie2	608478.456	4593861.268	204.2	204.87	3' X 1.5' P-50 Grate	--
500	Prie3	608478.588	4593841.9	204.08	204.76	3' X 1.5' P-50 Grate	--
501	Prie4	608497.863	4593838.368	203.74	204.87	3' X 1.5' P-50 Grate	--
502	Prie4A	608511.727	4593838.328	203.86	204.86	Invert	--
503	Prie5	608524.361	4593838.262	203.79	204	Invert	--
504	PV10	607574.006	4593932.032	203.96	204.94	8" Diameter Grate	--
505	PV12	607553.857	4593904.895	203.66	204.58	8" Diameter Grate	--
506	PV14a	607590.537	4593905.172	203.67	204.59	8" Diameter Grate	--
507	PV16a	607620.736	4593906.271	203.97	204.65	8" Diameter Grate	--
508	PV18	607616.508	4593915.973	204.08	204.79	8" Diameter Grate	--
509	PV2	607478.074	4593911.973	202.93	203.39	3' X 1.5' P-50 Grate	--
510	PV20	607617.395	4593958.377	204.5	205.23	8" Diameter Grate	--
511	PV22	607653.059	4593904.675	204.3	204.83	8" Diameter Grate	--
512	PV24	607713.791	4593903.921	204.92	205.43	8" Diameter Grate	--
513	PV26	607572.941	4594089.009	205.15	206.07	Sealed	--
514	PV3	607473.092	4593907.663	202.7	203.16	3' X 1.5' P-50 Grate	--
515	PV4	607516.157	4594057.494	203.07	204.54	2.8' X 2.8' Grate	--
516	PV6	607537.474	4594057.152	203.18	204.8	2.8' X 2.8' Grate	--
517	PV7	607553.509	4594052.543	205.02	205.38	Invert	--
518	PV9	607537.71	4593917.983	203.56	204.46	1.5' Diameter Grate	--
519	RRSD1	608937.102	4592977.106	199.33	200.43	8" Diameter Grate	--
520	Sal1	608047.539	4595508.125	208.89	213	Open	--
521	Sal10	607936.93	4594494.253	204.87	209	Open	--
522	Sal11	607890.588	4594427.935	204.55	209	Open	--
523	Sal12	607860.06	4594400.301	204.39	209	Open	--
524	Sal13	607832.218	4594386.57	204.18	209	Open	--
525	Sal14	607576.195	4594276.027	202.26	207	Open	--
526	Sal15	607568.044	4594270.809	202.26	207	Open	--
527	Sal16	607523.954	4594255.128	202.07	207	Open	--
528	Sal17	607466.895	4594242.922	201.84	207	Open	--
529	Sal18	607393.399	4594120.635	201.22	207	Open	--
530	Sal19	607390.301	4594076.09	201.04	206	Open	--
531	Sal2	608047.206	4595489.489	208.31	213	Open	--
532	Sal20	607388.112	4594057.11	200.97	206	Open	--
533	Sal21	607432.016	4593883.046	200.24	206	Open	--
534	Sal22	607471.248	4593799.92	199.87	205	Open	--
535	Sal23	607563.442	4593573.076	199.28	204	Open	--
536	Sal24	607594.873	4593509.491	199.12	203.62	Open	--
537	Sal25	607602.895	4593488.928	199.1	202.85	Open	--
538	Sal26	607650.084	4593392.601	198.97	203	Open	--
539	Sal27	607654.131	4593359.429	198.93	203	Open	--
540	Sal28	607663.846	4593312.528	198.88	202.68	Open	--

Table I-13: Information for Nodes 541 – 585

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
541	Sal29	607672.246	4593287.241	198.69	202.57	Open	--
542	Sal3.1	608037.911	4595284.074	207.93	212	Open	--
543	Sal30	607690.955	4593247.397	198.78	203	Open	--
544	Sal31	607716.515	4593211.109	198.86	202.75	Open	--
545	Sal32	607727.122	4593188.055	198.83	202	Open	--
546	Sal33	607737.845	4593128.705	198.23	202	Open	--
547	Sal34	607739.205	4593086.583	197.82	201	Open	--
548	Sal35	607738.081	4593061.104	197.85	201.4	Open	--
549	Sal36	607743.717	4592879.148	197.01	201	Open	--
550	Sal37	607745.853	4592694.682	196.46	201	Open	--
551	Sal38	607750.255	4592564.604	196.08	201	Open	--
552	Sal39	607752.762	4592344.3	195.28	200	Open	--
553	Sal4.1	608015.314	4595098.321	207.756	212	Open	--
554	Sal40	607752.259	4592337.643	195.38	200	Open	--
555	Sal41	607753.965	4592272.305	195.34	200	Open	--
556	Sal42	607756.608	4592040.26	195.28	200	Open	--
557	Sal43	607754.255	4592031.726	194.95	200	Open	--
558	Sal44	607755.416	4591975.517	194.03	200	Open	--
559	Sal45	607809.16	4591743.72	193.595	200	Open	--
560	Sal46	607818.723	4591691.465	193.52	199.64	Open	--
561	Sal5.1	608014.698	4595091.999	207.1	211.55	Open	--
562	Sal6.1	608015.441	4594924.674	205.98	211	Open	--
563	Sal7.1	608012.036	4594695.437	205.62	210	Open	--
564	Sal8.1	607997.509	4594652.175	205.55	210	Open	--
565	Sal9.1	607980.273	4594562.029	205.18	209	Open	--
566	Sch1	608183.458	4593698.129	200.34	202.44	Sealed	--
567	Sch2	608202.326	4593827.898	202.66	203.42	8" Diameter Grate	--
568	Sch3	608210.566	4593850.905	202.47	203.28	8" Diameter Grate	--
569	Sch4	608224.674	4593707.615	200.36	202.9	2' Diameter Grate	--
570	Sch5	608290.031	4593767.913	200.85	203.44	2' Diameter Grate	--
571	Sch6	608283.624	4593816.604	200.79	202.32	5' Diameter Grate	--
572	SMap1	608146.225	4592490.789	197.28	199.55	Invert	--
573	SMap11	608138.242	4592723.867	197.77	199.23	Invert	--
574	SMap12A	608156.697	4592704.713	197.89	199.46	Invert	--
575	SMap12B	608157.034	4592694.49	197.72	199.58	Invert	--
576	SMap14A	608154.96	4592748.093	197.93	199.26	Invert	--
577	SMap14B	608156.158	4592734.186	197.97	199.49	Invert	--
578	SMap16	608152.52	4592882.444	198.41	198.87	Default	--
579	SMap16B	608152.328	4592867.905	198.54	199.83	Invert	--
580	SMap17A	608135.434	4592885.747	198.17	199.48	Invert	--
581	SMap17B	608135.757	4592877.308	198.14	199.06	Invert	--
582	SMap18	608151.931	4592913.493	198.5	199.11	1' Diameter Grate	--
583	SMap1B	608166.144	4592478.563	197.44	199.52	Invert	--
584	SMap20	608150.743	4592937.725	198.48	199.09	1' Diameter Grate	--
585	SMap21A	608134.692	4592984.852	198.44	199.65	Invert	--

Table I-14: Information for Nodes 586 – 630

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
586	SMap21B	608135.354	4592945.925	198.31	199.62	Invert	--
587	SMap24	608149.753	4592980.021	198.59	199.2	1' Diameter Grate	--
588	SMap26	608149.827	4592990.01	198.63	199.24	1' Diameter Grate	--
589	SMap27	608134.016	4593015.149	198.55	199.47	3' X 1.5' Grate	--
590	SMap27B	608134.508	4592991.179	198.38	199.62	Invert	--
591	SMap28	608148.953	4593011.033	198.7	199.31	1' Diameter Grate	--
592	SMap3	608145.522	4592497.27	197.47	200	Invert	--
593	SMap30	608148.916	4593021.497	198.64	199.25	1' Diameter Grate	--
594	SMap4A	608161.482	4592590.292	198.27	199.61	Invert	--
595	SMap4B	608161.941	4592567.819	198.4	200.04	Invert	--
596	SMap5	608139.83	4592647.243	197.55	198.98	3' X 1.5' P-50 Grate	--
597	SMap5B	608140.852	4592609.754	197.65	199.33	Invert	--
598	SMap6	608157.304	4592683.556	197.86	199.62	Invert	--
599	SMap6B	608159.537	4592614.811	198.21	199.3	Invert	--
600	SMap9	608139.475	4592691.315	197.65	198.82	3' X 1.5' P-50 Grate	--
601	SNut10A	608953.889	4593187.973	199.93	200.39	Invert	--
602	SNut10B	608955.159	4593176.862	199.91	200.56	Invert	--
603	SNut11A	608936.844	4593201.808	199.91	200.37	Invert	--
604	SNut11B	608937.041	4593189.647	199.89	200.35	Invert	--
605	SNut13A	608937.238	4593256.601	200.12	201.1	Invert	--
606	SNut13B	608937.305	4593246.772	200.01	200.47	Invert	--
607	SNut15A	608936.644	4593297.883	200.45	201.1	Invert	--
608	SNut15B	608936.772	4593288.582	200.37	201.24	Invert	--
609	SNut17A	608935.529	4593391.997	200.98	201.96	Invert	--
610	SNut17B	608936.579	4593308.544	200.72	201.36	Invert	--
611	SNut18A	608957.042	4593501.669	202.01	202.62	Invert	--
612	SNut18B	608954.961	4593490.011	201.84	202.45	Invert	--
613	SNut1A	608940.611	4592848.229	200.27	200.61	Invert	--
614	SNut1B	608940.4	4592865.751	200.12	201.38	Invert	--
615	SNut3	608937.243	4593073.007	199.35	200.44	Invert	--
616	SNut3B	608933.967	4593060.545	199.24	199.9	Invert	--
617	SNut4	608952.736	4593068.93	199.6	200.06	Invert	--
618	SNut6	608953.124	4593082.481	199.51	200.52	Invert	--
619	SNut7A	608938.112	4593133.081	199.79	200.25	Invert	--
620	SNut7B	608938.311	4593120.759	199.65	200.89	Invert	--
621	SNut8A	608952.128	4593124.35	199.98	200.99	Invert	--
622	SNut8B	608955.362	4593143.25	199.84	200.5	Invert	--
623	SNut9A	608937.398	4593160.393	199.82	200.28	Invert	--
624	SNut9B	608937.495	4593143.727	199.83	200.29	Invert	--
625	Soft1	608632.012	4593659.779	201.5	202.72	2' Diameter Grate	--
626	UPSal2	608027.294	4595665.131	210.51	211.82	Sealed	--
627	UPSal3	608102.945	4595689.737	211.2	211.98	4' X 4' Diameter Grate	--
628	UPSal4	607991.161	4596117.298	213.37	214.23	Sealed	--
629	UPSal5	608089.09	4596210.788	213.79	214.82	4' X 4' Diameter Grate	--
630	UPSal6	607816.939	4596301.151	214.98	215.83	4' X 4' Diameter Grate	--

Table I-15: Information for Nodes 631 – 673

Number	Node	X Coordinate (m)	Y Coordinate (m)	Invert Elevation (m)	Ground Elevation (m)	Connection to Grid	Surface Slope (%)
631	W1251A	608452.721	4592295.029	196.87	198.77	Invert	--
632	W1251B	608484.608	4592294.463	196.85	199.11	Invert	--
633	W1252	608538.728	4592294.555	196.82	199.08	Invert	--
634	W2ndSt2	607180.621	4593987.872	203.23	204.03	4' Curb Inlet	--
635	W2St1	607173.171	4593987.999	203.11	204.02	4' Curb Inlet	--
636	W2St3	607173.414	4594051.913	202.61	203.67	4' Curb Inlet	--
637	W2St4	607180.764	4594052.087	202.71	203.71	4' Curb Inlet	--
638	W2St5	607173.378	4594083.06	202.86	203.74	4' Curb Inlet	--
639	W2St6	607180.841	4594083.08	203.01	203.77	4' Curb Inlet	--
640	W2St7	607173.646	4594177.301	203.25	204.23	9' Curb Inlet	--
641	W2St8	607180.947	4594177.242	203.5	204.24	9' Curb Inlet	--
642	W3rdSt7	607082.663	4594083.729	202.56	203.31	9' Curb Inlet	--
643	W3rdSt8	607091.744	4594083.496	202.66	203.33	9' Curb Inlet	--
644	W3St1B	607045.012	4593961.175	202.05	202.36	Invert	--
645	W3St3	607082.321	4593961.691	202.41	203.5	4' Curb Inlet	--
646	W3St4	607091.515	4593961.612	202.54	203.48	4' Curb Inlet	--
647	W3St6	607091.702	4594050.539	202.43	203.25	9' Curb Inlet	--
648	W4th2	606988.086	4594102.27	202.34	203.48	9' Curb Inlet	--
649	W4th2B	606988.733	4594043.705	202.09	203.13	Invert	--
650	W4th3	606978.963	4594102.703	202.54	203.47	9' Curb Inlet	--
651	WHAve1	606929.228	4594080.033	202.57	203.39	4' Curb Inlet	--
652	WHAve10	607035.252	4594166.286	202.56	203.47	Invert	--
653	WHAve11	607070.888	4594061.638	202.31	203.39	4' Curb Inlet	--
654	WHAve11B	607038.544	4594048.66	202.15	203.07	Invert	--
655	WHAve12	607072.79	4594073.807	202.38	203.43	4' Curb Inlet	--
656	WHAve15	607082.532	4594051.35	202.35	203.27	9' Curb Inlet	--
657	WHAve17	607132.93	4594060.847	202.27	203.44	4' Curb Inlet	--
658	WHAve18	607132.877	4594073.401	202.39	203.43	4' Curb Inlet	--
659	WHAve1B	606938.511	4594035.149	202.17	203.13	Invert	--
660	WHAve20	607131.591	4594081.617	202.61	203.25	1' Diameter Grate	--
661	WHAve22	607130.131	4594163.687	202.82	203.45	1' Diameter Grate	--
662	WHAve25	607223.815	4594061.43	203.37	204.25	4' Curb Inlet	--
663	WHAve26	607223.744	4594073.669	203.44	204.25	4' Curb Inlet	--
664	WHave28	607223.366	4594082.755	203.52	204.24	Invert	--
665	WHave29	607239.086	4594060.508	203.81	204.75	4' Curb Inlet	--
666	WHAve3	606929.307	4594092.307	202.74	203.44	4' Curb Inlet	--
667	WhAve31	607249.648	4594049.769	204.82	205.26	4' Curb Inlet	--
668	WHAve33	607237.13	4593998.057	204.32	205	Invert	--
669	WHAve35	607241.927	4593998.465	203.93	204.32	Invert	--
670	WHAve4	606929.966	4594101.334	202.94	203.26	Invert	--
671	WHAve7	607035.604	4594064.977	202.1	204.21	Sealed	--
672	WHAve7B	607035.357	4594049.346	202.18	203.1	Invert	--
673	WHAve8	607034.771	4594096.823	202.28	203.18	2' Diameter Grate	--

APPENDIX J. INPUT PARAMETERS FOR SALVESEN CREEK CULVERTS AT E, C, B, AND A AVENUES AND EAST DRAINAGE DITCH MODIFICATION AT E AVENUE

Table J-1: Input Parameters for Salvesen Creek at E Avenue

Salvesen Creek at E Avenue			
Depth (m)	Area (sq m)	Wetted Perimeter (m)	Top Width (m)
3.03	24.62	14.28	11.74
2.96	23.83	14.03	11.54
2.81	22.09	13.65	11.34
2.66	20.37	13.31	11.20
2.51	18.67	12.99	11.12
2.35	16.98	12.68	11.03
2.20	15.31	12.27	10.82
2.05	13.69	11.77	10.48
1.90	12.12	11.25	10.12
1.74	10.61	10.69	9.72
1.59	9.15	10.21	9.40
1.44	7.75	9.62	8.95
1.29	6.46	8.18	7.58
1.13	5.35	7.50	6.97
0.98	4.33	6.86	6.41
0.83	3.39	6.29	5.94
0.68	2.52	5.72	5.46
0.52	1.73	5.11	4.93
0.37	1.02	4.49	4.38
0.22	0.41	3.35	3.31
0.07	0.06	1.46	1.45
0.00	0.00	0.00	0.00

Table J-2: Salvesen Creek at C Avenue Input Parameters

Salvesen Creek at C Avenue			
Depth (m)	Area (sq m)	Wetted Perimeter (m)	Top Width (m)
3.048	25.126	20.416	8.263
2.898	23.884	19.815	8.261
2.745	22.625	19.205	8.259
2.593	21.367	18.596	8.257
2.440	20.108	17.986	8.255
2.288	18.850	17.376	8.253
2.136	17.593	16.767	8.251
1.983	16.335	16.157	8.249
1.831	15.078	15.548	8.247
1.678	13.821	14.938	8.246
1.526	12.565	14.328	8.244
1.374	11.309	13.719	8.242
1.221	10.053	13.109	8.240
1.069	8.797	12.500	8.238
0.916	7.542	11.890	8.236
0.764	6.287	11.280	8.234
0.612	5.032	10.671	8.232
0.459	3.778	10.061	8.230
0.307	2.524	9.451	8.228
0.154	1.270	8.842	8.226
0.002	0.016	8.232	8.224
0.000	0.000	0.000	0.000

Table J-3: Salvesen Creek at B Avenue Input Parameters

Salvesen Creek at B Avenue			
Depth (m)	Area (sq m)	Wetted Perimeter (m)	Top Width (m)
3.048	22.528	19.566	7.408
2.918	21.562	19.044	7.407
2.765	20.433	18.435	7.405
2.613	19.305	17.825	7.403
2.460	18.177	17.215	7.402
2.308	17.049	16.606	7.400
2.156	15.921	15.996	7.398
2.003	14.794	15.387	7.396
1.851	13.667	14.777	7.395
1.698	12.540	14.167	7.393
1.546	11.413	13.558	7.391
1.394	10.287	12.948	7.390
1.241	9.161	12.339	7.388
1.089	8.035	11.729	7.386
0.936	6.910	11.119	7.384
0.784	5.784	10.510	7.383
0.632	4.659	9.900	7.381
0.479	3.535	9.290	7.379
0.327	2.410	8.681	7.377
0.174	1.286	8.071	7.376
0.022	0.162	7.462	7.374
0.000	0.000	0.000	0.000

Table J-4: Salvesen Creek at A Avenue Input Parameters

Salvesen Creek at A Avenue			
Depth (m)	Area (sq m)	Wetted Perimeter (m)	Top Width (m)
3.048	26.013	20.720	8.540
2.896	24.711	20.111	8.540
2.743	23.410	19.501	8.539
2.591	22.109	18.892	8.539
2.438	20.807	18.282	8.538
2.286	19.506	17.672	8.537
2.134	18.205	17.063	8.537
1.981	16.904	16.453	8.536
1.829	15.603	15.844	8.536
1.676	14.302	15.234	8.535
1.524	13.002	14.624	8.534
1.372	11.701	14.015	8.534
1.219	10.401	13.405	8.533
1.067	9.100	12.796	8.533
0.914	7.800	12.186	8.532
0.762	6.500	11.576	8.531
0.610	5.200	10.967	8.531
0.457	3.900	10.357	8.530
0.305	2.600	9.748	8.530
0.152	1.300	9.138	8.529
0.000	0.000	0.000	0.000

Table J-5: East Drainage Ditch at A Avenue Input Parameters

East Drainage Ditch at A Avenue			
Depth (m)	Area (sq m)	Wetted Perimeter (m)	Top Width (m)
0	0	0	0
0.11	0.14	1.82	1.79
0.26	0.5	2.87	2.75
0.41	0.94	3.31	2.95
0.57	1.39	3.62	2.96
0.72	1.84	3.92	2.97
0.87	2.37	5.95	4.54
1.02	3.2	8.34	6.31
1.18	4.28	10.43	7.79
1.33	5.57	12.4	9.14
1.48	7.07	14.37	10.49
1.51	7.33	14.68	10.71

Table J-6: Input Parameters for the East Drainage Ditch Modifications at E Avenue

East Drainage Ditch at E Avenue			
Depth (m)	Area (sq m)	Wetted Perimeter (m)	Top Width (m)
3.048	26.013	20.720	8.540
2.896	24.711	20.111	8.540
2.743	23.410	19.501	8.539
2.591	22.109	18.892	8.539
2.438	20.807	18.282	8.538
2.286	19.506	17.672	8.537
2.134	18.205	17.063	8.537
1.981	16.904	16.453	8.536
1.829	15.603	15.844	8.536
1.676	14.302	15.234	8.535
1.524	13.002	14.624	8.534
1.372	11.701	14.015	8.534
1.219	10.401	13.405	8.533
1.067	9.100	12.796	8.533
0.914	7.800	12.186	8.532
0.762	6.500	11.576	8.531
0.610	5.200	10.967	8.531
0.457	3.900	10.357	8.530
0.305	2.600	9.748	8.530
0.152	1.300	9.138	8.529
0.000	0.000	0.000	0.000

APPENDIX K. DOWNSTREAM ENGLISH RIVER BOUNDARY CONDITIONS

Table K-2: 2D Downstream Head Boundary Conditions

Return Period (year)	Downstream English River Stage (m)									
	Reach									
	1	2	3	4	5	6	7	8	9	10
2	195.91	195.80	195.71	195.63	195.49	195.40	195.35	195.22	195.16	195.03
5	196.20	196.07	195.95	195.85	195.68	195.56	195.50	195.34	195.26	195.11
10	196.53	196.39	196.25	196.14	195.96	195.83	195.76	195.59	195.50	195.33
25	197.11	196.96	196.82	196.70	196.51	196.37	196.29	196.11	196.01	195.83
50	197.59	197.44	197.29	197.17	196.97	196.83	196.76	196.56	196.47	196.28
100	198.48	198.32	198.17	198.04	197.84	197.69	197.62	197.42	197.32	197.13
200	198.52	198.36	198.21	198.08	197.88	197.73	197.65	197.46	197.36	197.17
500	198.57	198.41	198.27	198.14	197.94	197.79	197.72	197.52	197.42	197.24
1000	198.61	198.45	198.30	198.18	197.98	197.83	197.75	197.56	197.46	197.27

Table K-1: 1D Downstream Head Boundary Conditions

Downstream English River Stage (m)			
Return Period (year)	Salvesen Creek Outfall	Central Drainage Ditch Outfall	East Drainage Ditch Outfall
2	195.78	195.38	195.03
5	196.04	195.55	195.11
10	196.36	195.81	195.33
25	196.93	196.35	195.83
50	197.41	196.81	196.28
100	198.28	197.67	197.13
200	198.32	197.71	197.17
500	198.38	197.77	197.24
1000	198.42	197.81	197.27

APPENDIX L. DETENTION BASIN STAGE-STORAGE RELATIONSHIPS

Table L-1: Stage-Storage Relationship for Basin 1

Basin 1						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	214.38	0.00	0.00	0.00	0.00	0.00
0.50	214.88	193.09	0.05	32.75	0.03	0.00
1.00	215.38	944.38	0.23	287.96	0.23	0.00
1.50	215.88	2407.36	0.59	1096.13	0.89	0.00
2.00	216.38	4561.28	1.13	2803.78	2.27	1.11
2.50	216.88	7146.92	1.77	5727.02	4.64	3.48
3.00	217.38	10175.16	2.51	10029.18	8.13	6.97
3.50	217.88	13510.19	3.34	15961.12	12.94	11.77
4.00	218.38	16836.98	4.16	23524.71	19.07	17.91
4.50	218.88	20651.58	5.10	32875.93	26.65	25.49
5.00	219.38	24558.42	6.07	44169.74	35.81	34.64
5.50	219.88	28850.76	7.13	57507.31	46.62	45.46
6.00	220.38	33394.84	8.25	73053.62	59.23	58.06

Table L-2: Stage-Storage Relationship for Basin 2

Basin 2						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	222.07	0.00	0.00	0.00	0.00	0.00
0.50	222.57	186.37	0.05	25.92	0.02	0.00
1.00	223.07	1343.09	0.33	350.41	0.28	0.00
1.50	223.57	3326.39	0.82	1501.19	1.22	0.00
2.00	224.07	5851.68	1.45	3760.07	3.05	1.47
2.50	224.57	9051.10	2.24	7507.78	6.09	4.50
3.00	225.07	11996.64	2.96	12769.46	10.35	8.77
3.50	225.57	15545.73	3.84	19632.60	15.92	14.33
4.00	226.07	19043.43	4.71	28275.66	22.92	21.34
4.50	226.57	22312.29	5.51	38627.22	31.32	29.73
5.00	227.07	25983.22	6.42	50631.59	41.05	39.46
5.50	227.57	30550.47	7.55	64785.23	52.52	50.94
6.00	228.07	34865.41	8.62	81105.26	65.75	64.17

Table L-3: Stage-Storage Relationship for Basin 3

Basin 3						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	221.08	0.00	0.00	0.00	0.00	0.00
0.50	221.58	225.11	0.06	40.06	0.03	0.00
1.00	222.08	999.36	0.25	304.17	0.25	0.00
1.50	222.58	2071.90	0.51	1047.94	0.85	0.00
2.00	223.08	3586.69	0.89	2450.81	1.99	0.91
2.50	223.58	5110.16	1.26	4606.21	3.73	2.66
3.00	224.08	7372.59	1.82	7685.70	6.23	5.15
3.50	224.58	9902.93	2.45	11979.26	9.71	8.63
4.00	225.08	12919.55	3.19	17656.80	14.31	13.24
4.50	225.58	16590.93	4.10	25001.43	20.27	19.19
5.00	226.08	20409.42	5.04	34245.07	27.76	26.69
5.50	226.58	24287.85	6.00	45416.68	36.82	35.74
6.00	227.08	28419.04	7.02	58557.66	47.47	46.40

Table L-4: Stage-Storage Relationship for Basin 4

Basin 4						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	222.16	0.00	0.00	0.00	0.00	0.00
0.50	222.66	447.47	0.11	72.78	0.06	0.00
1.00	223.16	1742.17	0.43	591.66	0.48	0.00
1.50	223.66	3776.12	0.93	1919.09	1.56	0.00
2.00	224.16	6505.35	1.61	4464.00	3.62	1.65
2.50	224.66	9777.40	2.42	8539.73	6.92	4.95
3.00	225.16	12834.18	3.17	14183.17	11.50	9.53
3.50	225.66	16118.94	3.98	21409.95	17.36	15.39
4.00	226.16	19751.22	4.88	30376.55	24.63	22.66
4.50	226.66	23510.08	5.81	41189.39	33.39	31.42
5.00	227.16	27665.64	6.84	53957.22	43.74	41.78
5.50	227.66	32166.39	7.95	68900.86	55.86	53.89
6.00	228.16	36869.76	9.11	86155.05	69.85	67.88

Table L-5: Stage-Storage Relationship for Basin 5

Basin 5						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	221.47	0.00	0.00	0.00	0.00	0.00
0.50	221.97	332.25	0.08	63.36	0.05	0.00
1.00	222.47	1028.05	0.25	389.00	0.32	0.00
1.50	222.97	1978.50	0.49	1129.39	0.92	0.00
2.00	223.47	3273.83	0.81	2425.75	1.97	0.84
2.50	223.97	4760.81	1.18	4436.51	3.60	2.47
3.00	224.47	5994.86	1.48	7134.21	5.78	4.66
3.50	224.97	7256.21	1.79	10406.58	8.44	7.31
4.00	225.47	10799.93	2.67	14901.50	12.08	10.96
4.50	225.97	14099.62	3.48	21144.37	17.14	16.02
5.00	226.47	17690.07	4.37	29069.79	23.57	22.44
5.50	226.97	21480.34	5.31	38867.75	31.51	30.38
6.00	227.47	25085.48	6.20	50496.99	40.94	39.81

Table L-6: Stage-Storage Relationship for Basin 6

Basin 6						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	221.22	0.00	0.00	0.00	0.00	0.00
0.50	221.72	389.55	0.10	80.43	0.07	0.00
1.00	222.22	1351.75	0.33	494.94	0.40	0.00
1.50	222.72	2509.39	0.62	1453.79	1.18	0.00
2.00	223.22	3892.92	0.96	3032.74	2.46	1.02
2.50	223.72	5997.45	1.48	5484.45	4.45	3.01
3.00	224.22	8252.74	2.04	9035.91	7.33	5.89
3.50	224.72	10687.64	2.64	13768.54	11.16	9.73
4.00	225.22	13516.10	3.34	19796.50	16.05	14.61
4.50	225.72	16701.73	4.13	27331.65	22.16	20.72
5.00	226.22	20074.87	4.96	36526.78	29.61	28.18
5.50	226.72	23333.92	5.77	47379.24	38.41	36.98
6.00	227.22	26330.54	6.51	59791.27	48.47	47.04

Table L-7: Stage-Storage Relationship for Basin 7

Basin 7						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	222.64	0.00	0.00	0.00	0.00	0.00
0.50	223.14	221.06	0.05	40.68	0.03	0.00
1.00	223.64	876.83	0.22	292.74	0.24	0.00
1.50	224.14	2118.56	0.52	1007.67	0.82	0.00
2.00	224.64	3945.15	0.97	2523.12	2.05	0.98
2.50	225.14	6003.61	1.48	5014.89	4.07	3.00
3.00	225.64	8107.41	2.00	8532.73	6.92	5.85
3.50	226.14	10426.96	2.58	13162.34	10.67	9.61
4.00	226.64	13071.64	3.23	19011.12	15.41	14.35
4.50	227.14	16428.84	4.06	26399.64	21.40	20.34
5.00	227.64	19882.75	4.91	35454.75	28.74	27.68
5.50	228.14	23744.51	5.87	46334.91	37.56	36.50
6.00	228.64	27984.51	6.92	59256.88	48.04	46.98

Table L-8: Stage-Storage Relationship for Basin 8

Basin 8						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	222.50	0.00	0.00	0.00	0.00	0.00
0.50	223.00	293.98	0.07	57.58	0.05	0.00
1.00	223.50	1088.18	0.27	377.18	0.31	0.00
1.50	224.00	2339.74	0.58	1209.80	0.98	0.00
2.00	224.50	4079.09	1.01	4084.16	3.31	1.86
2.50	225.00	6073.16	1.50	5329.06	4.32	2.87
3.00	225.50	8596.00	2.12	8973.25	7.27	5.83
3.50	226.00	11511.21	2.84	13983.69	11.34	9.89
4.00	226.50	14632.38	3.62	20505.57	16.62	15.18
4.50	227.00	18301.94	4.52	28711.61	23.28	21.83
5.00	227.50	22353.64	5.52	38854.70	31.50	30.05
5.50	228.00	26660.12	6.59	51097.78	41.43	39.98
6.00	228.50	31610.92	7.81	65632.37	53.21	51.76

Table L-9: Stage-Storage Relationship for Basin 9

Basin 9						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	213.42	0.00	0.00	0.00	0.00	0.00
0.50	213.92	220.79	0.05	36.19	0.03	0.00
1.00	214.42	1189.63	0.29	347.07	0.28	0.00
1.50	214.92	2926.31	0.72	1355.30	1.10	0.00
2.00	215.42	5045.00	1.25	3334.33	2.70	1.28
2.50	215.92	7313.23	1.81	6415.47	5.20	3.78
3.00	216.42	9797.24	2.42	10691.10	8.67	7.25
3.50	216.92	12278.89	3.03	16197.23	13.13	11.71
4.00	217.42	15384.17	3.80	23084.68	18.72	17.30
4.50	217.92	18945.64	4.68	31638.44	25.65	24.23
5.00	218.42	23010.88	5.69	42130.17	34.16	32.74
5.50	218.92	27099.55	6.70	54657.25	44.31	42.89
6.00	219.42	31045.63	7.67	69183.52	56.09	54.67

Table L-10: Stage-Storage Relationship for Basin 10

Basin 10						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	212.57	0.00	0.00	0.00	0.00	0.00
0.50	213.07	841.43	0.21	157.68	0.13	0.00
1.00	213.57	2500.06	0.62	964.45	0.78	0.00
1.50	214.07	4417.08	1.09	2695.42	2.19	0.00
2.00	214.57	6389.31	1.58	5382.29	4.36	1.74
2.50	215.07	8432.53	2.08	9083.34	7.36	4.74
3.00	215.57	10434.69	2.58	13786.64	11.18	8.56
3.50	216.07	13007.24	3.21	19648.06	15.93	13.31
4.00	216.57	15620.58	3.86	26786.17	21.72	19.10
4.50	217.07	18818.52	4.65	35381.09	28.68	26.06
5.00	217.57	22013.81	5.44	45585.96	36.96	34.34
5.50	218.07	25277.00	6.25	57407.50	46.54	43.92
6.00	218.57	28632.61	7.08	70878.31	57.46	54.84

Table L-11: Stage-Storage Relationship for Basin 11

Basin 11						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	214.41	0.00	0.00	0.00	0.00	0.00
0.50	214.91	1215.62	0.30	257.59	0.21	0.00
1.00	215.41	2532.64	0.63	1164.65	0.94	0.00
1.50	215.91	4558.56	1.13	2951.78	2.39	0.00
2.00	216.41	6599.60	1.63	5721.34	4.64	1.80
2.50	216.91	9034.48	2.23	9610.97	7.79	4.95
3.00	217.41	12019.62	2.97	14856.98	12.04	9.20
3.50	217.91	15092.72	3.73	21637.86	17.54	14.70
4.00	218.41	18355.97	4.54	29983.33	24.31	21.47
4.50	218.91	22007.27	5.44	40060.06	32.48	29.64
5.00	219.41	26022.07	6.43	52062.33	42.21	39.37
5.50	219.91	30405.88	7.51	66306.02	53.76	50.91
6.00	220.41	34903.12	8.62	82615.72	66.98	64.14

Table L-12: Stage-Storage Relationship for Basin 12

Basin 12						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	218.88	0.00	0.00	0.00	0.00	0.00
0.50	219.38	81.00	0.02	12.89	0.01	0.00
1.00	219.88	361.53	0.09	102.26	0.08	0.00
1.50	220.38	1204.78	0.30	454.30	0.37	0.00
2.00	220.88	2590.87	0.64	1385.64	1.12	0.60
2.50	221.38	4334.10	1.07	3082.90	2.50	1.98
3.00	221.88	6485.67	1.60	5774.18	4.68	4.16
3.50	222.38	9056.36	2.24	9633.25	7.81	7.29
4.00	222.88	12157.57	3.00	14922.03	12.10	11.58
4.50	223.38	15322.80	3.79	21794.06	17.67	17.15
5.00	223.88	18305.44	4.52	30199.36	24.48	23.96
5.50	224.38	22068.75	5.45	40186.79	32.58	32.06
6.00	224.88	26689.97	6.60	52366.12	42.45	41.93

Table L-13: Stage-Storage Relationship for Basin 13

Basin 13						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	217.43	0.00	0.00	0.00	0.00	0.00
0.50	217.93	78.20	0.02	9.69	0.01	0.00
1.00	218.43	389.20	0.10	113.78	0.09	0.00
1.50	218.93	998.77	0.25	442.65	0.36	0.00
2.00	219.43	2068.34	0.51	1190.02	0.96	0.48
2.50	219.93	3656.02	0.90	2617.61	2.12	1.64
3.00	220.43	5280.57	1.30	4844.37	3.93	3.45
3.50	220.93	7167.44	1.77	7941.00	6.44	5.96
4.00	221.43	9337.41	2.31	12053.10	9.77	9.29
4.50	221.93	11548.32	2.85	17276.62	14.01	13.53
5.00	222.43	13942.91	3.45	23631.49	19.16	18.68
5.50	222.93	16794.68	4.15	31321.72	25.39	24.91
6.00	223.43	19722.75	4.87	40437.73	32.78	32.30

Table L-14: Stage-Storage Relationship for Basin 14

Basin 14						
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)	Temporary Storage (acre-ft)
0.00	212.16	0.00	0.00	0.00	0.00	0.00
0.50	212.66	419.54	0.10	81.46	0.07	0.00
1.00	213.16	1553.43	0.38	541.55	0.44	0.00
1.50	213.66	3174.82	0.78	1706.43	1.38	0.00
2.00	214.16	5307.23	1.31	3807.50	3.09	1.36
2.50	214.66	7818.23	1.93	7078.76	5.74	4.01
3.00	215.16	10653.85	2.63	11673.85	9.46	7.74
3.50	215.66	13876.06	3.43	17799.75	14.43	12.71
4.00	216.16	17416.41	4.30	25608.65	20.76	19.04
4.50	216.66	21400.28	5.29	35285.17	28.61	26.88
5.00	217.16	26104.40	6.45	47129.18	38.21	36.48
5.50	217.66	31280.92	7.73	61460.31	49.83	48.10
6.00	218.16	36909.71	9.12	78502.77	63.64	61.92

Table L-15: Stage-Storage Relationship for the Softball Fields' Basin

Softball Fields Basin					
Depth (m)	Elevation	Area (sq m)	Area (acres)	Storage (cu m)	Storage (acre-ft)
0	202.132	0.000	0.000	0.000	0.000
0.5	202.632	3495.694	0.864	535.651	0.434
1	203.132	6850.591	1.693	3199.845	2.594
1.5	203.632	9342.036	2.308	7259.794	5.886
2	204.132	11382.980	2.813	12515.06827	10.146
2.5	204.632	12393.017	3.062	18464.219	14.969
3	205.132	13138.562	3.247	24869.214	20.162
3.5	205.632	13365.656	3.303	31503.190	25.540

Table L-16: Upstream Detention Pond Area and Storage Information

Basin	Base Elevation (m)	Pool Elevation (m)	Spillway Elevation (m)	Embankment Elevation (m)	Height of Spillway (m)	Depth to Spillway (m)	Depth to Top of Embankment (m)	Permanent Storage Area (acres)	Temporary Storage Area to Spillway (acres)	Temporary Storage Area to Embankment (acres)	Permanent Storage (acre-ft)	Temporary Storage to Spillway (acre-ft)	Maximum Storage (acre-ft)
1	214.38	215.98	218.51	219.61	1.10	4.13	5.23	0.70	4.41	6.55	1.17	19.88	39.57
2	222.07	223.67	225.29	226.24	0.95	3.22	4.17	0.95	3.36	4.99	1.58	11.26	24.25
3	221.08	222.68	225.34	226.35	1.01	4.26	5.27	0.59	3.66	5.56	1.08	16.33	31.53
4	222.16	223.76	225.61	226.69	1.08	3.45	4.53	1.07	3.90	5.87	1.97	14.80	32.04
5	221.48	223.08	226.06	227.32	1.26	4.58	5.84	0.55	3.63	5.91	1.13	17.04	36.81
6	221.22	222.82	225.32	226.41	1.09	4.10	5.19	0.69	3.50	5.27	1.43	15.84	31.57
7	222.64	224.24	226.35	227.43	1.08	3.71	4.79	0.61	2.85	4.55	1.06	11.60	24.55
8	222.50	224.10	226.48	227.61	1.13	3.98	5.11	0.66	3.58	5.75	1.45	14.97	32.21
9	213.42	215.02	217.10	218.29	1.19	3.68	4.87	0.83	3.31	5.43	1.42	13.72	30.53
10	212.57	214.17	215.68	216.53	0.85	3.11	3.96	1.19	2.72	3.81	2.62	9.60	18.65
11	214.42	216.02	217.96	219.28	1.32	3.54	4.86	1.23	3.79	6.15	2.84	15.24	36.59
12	218.88	220.48	223.47	224.52	1.05	4.59	5.64	0.37	3.92	5.78	0.52	18.38	34.92
13	217.43	219.03	221.73	222.78	1.05	4.30	5.35	0.30	2.64	3.94	0.48	11.83	23.07
14	212.16	213.76	216.24	217.07	0.83	4.08	4.91	0.89	4.46	6.25	1.72	20.29	34.82

Table L-17: Emergency Spillway Inlet Rating Curves for Detention Ponds 1-3

Basin 1	
Depth (m)	Flow (cms)
2.53	0.00
2.58	0.19
2.63	0.61
2.68	1.22
2.73	2.02
2.78	2.98
2.83	4.13
2.88	5.45
2.93	6.95
2.98	8.64
3.03	10.52
3.08	12.59
3.13	14.86
3.18	17.33
3.23	20.02
3.28	22.92
3.33	26.03
3.38	29.38
3.43	32.95
3.48	36.76
3.53	40.80
3.58	45.10
3.63	49.64

Basin 2	
Depth (m)	Flow (cms)
1.62	0.00
1.67	0.19
1.72	0.61
1.77	1.22
1.82	2.02
1.87	2.98
1.92	4.13
1.97	5.45
2.02	6.95
2.07	8.64
2.12	10.52
2.17	12.59
2.22	14.86
2.27	17.33
2.32	20.02
2.37	22.92
2.42	26.03
2.47	29.38
2.52	32.95
2.57	36.76
2.62	40.80
2.67	45.10

Basin 3	
Depth (m)	Flow (cms)
2.66	0.00
2.71	0.19
2.76	0.61
2.81	1.22
2.86	2.02
2.91	2.98
2.96	4.13
3.01	5.45
3.06	6.95
3.11	8.64
3.16	10.52
3.21	12.59
3.26	14.86
3.31	17.33
3.36	20.02
3.41	22.92
3.46	26.03
3.51	29.38
3.56	32.95
3.61	36.76
3.66	40.80
3.71	45.10

Table L-18: Emergency Spillway Inlet Rating Curves for Detention Ponds 4-6

Basin 4	
Depth (m)	Flow (cms)
1.85	0.00
1.90	0.19
1.95	0.61
2.00	1.22
2.05	2.02
2.10	2.98
2.15	4.13
2.20	5.45
2.25	6.95
2.30	8.64
2.35	10.52
2.40	12.59
2.45	14.86
2.50	17.33
2.55	20.02
2.60	22.92
2.65	26.03
2.70	29.38
2.75	32.95
2.80	36.76
2.85	40.80
2.90	45.10
2.95	49.64

Basin 5	
Depth (m)	Flow (cms)
2.98	0.00
3.03	0.19
3.08	0.61
3.13	1.22
3.18	2.02
3.23	2.98
3.28	4.13
3.33	5.45
3.38	6.95
3.43	8.64
3.48	10.52
3.53	12.59
3.58	14.86
3.63	17.33
3.68	20.02
3.73	22.92
3.78	26.03
3.83	29.38
3.88	32.95
3.93	36.76
3.98	40.80
4.03	45.10
4.08	49.64
4.13	54.44
4.18	59.50
4.23	64.82
4.28	70.41

Basin 6	
Depth (m)	Flow (cms)
2.50	0.00
2.55	0.19
2.60	0.61
2.65	1.22
2.70	2.02
2.75	2.98
2.80	4.13
2.85	5.45
2.90	6.95
2.95	8.64
3.00	10.52
3.05	12.59
3.10	14.86
3.15	17.33
3.20	20.02
3.25	22.92
3.30	26.03
3.35	29.38
3.40	32.95
3.45	36.76
3.50	40.80
3.55	45.10
3.60	49.64

Table L-19: Emergency Spillway Inlet Rating Curves for Detention Ponds 7-9

Basin 7	
Depth (m)	Flow (cms)
2.11	0.00
2.16	0.19
2.21	0.61
2.26	1.22
2.31	2.02
2.36	2.98
2.41	4.13
2.46	5.45
2.51	6.95
2.56	8.64
2.61	10.52
2.66	12.59
2.71	14.86
2.76	17.33
2.81	20.02
2.86	22.92
2.91	26.03
2.96	29.38
3.01	32.95
3.06	36.76
3.11	40.80
3.16	45.10
3.21	49.64

Basin 8	
Depth (m)	Flow (cms)
2.38	0.00
2.43	0.19
2.48	0.61
2.53	1.22
2.58	2.02
2.63	2.98
2.68	4.13
2.73	5.45
2.78	6.95
2.83	8.64
2.88	10.52
2.93	12.59
2.98	14.86
3.03	17.33
3.08	20.02
3.13	22.92
3.18	26.03
3.23	29.38
3.28	32.95
3.33	36.76
3.38	40.80
3.43	45.10
3.48	49.64
3.53	54.44

Basin 9	
Depth (m)	Flow (cms)
2.08	0.00
2.13	0.19
2.18	0.61
2.23	1.22
2.28	2.02
2.33	2.98
2.38	4.13
2.43	5.45
2.48	6.95
2.53	8.64
2.58	10.52
2.63	12.59
2.68	14.86
2.73	17.33
2.78	20.02
2.83	22.92
2.88	26.03
2.93	29.38
2.98	32.95
3.03	36.76
3.08	40.80
3.13	45.10
3.18	49.64
3.23	54.44
3.28	59.50

Table L-20: Emergency Spillway Inlet Rating Curves for Detention Ponds 10-12

Basin 10	
Depth (m)	Flow (cms)
1.51	0.00
1.56	0.19
1.61	0.61
1.66	1.22
1.71	2.02
1.76	2.98
1.81	4.13
1.86	5.45
1.91	6.95
1.96	8.64
2.01	10.52
2.06	12.59
2.11	14.86
2.16	17.33
2.21	20.02
2.26	22.92
2.31	26.03
2.36	29.38

Basin 11	
Depth (m)	Flow (cms)
1.94	0.00
1.99	0.19
2.04	0.61
2.09	1.22
2.14	2.02
2.19	2.98
2.24	4.13
2.29	5.45
2.34	6.95
2.39	8.64
2.44	10.52
2.49	12.59
2.54	14.86
2.59	17.33
2.64	20.02
2.69	22.92
2.74	26.03
2.79	29.38
2.84	32.95
2.89	36.76
2.94	40.80
2.99	45.10
3.04	49.64
3.09	54.44
3.14	59.50
3.19	64.82
3.24	70.41
3.29	76.28

Basin 12	
Depth (m)	Flow (cms)
2.99	0.00
3.04	0.19
3.09	0.61
3.14	1.22
3.19	2.02
3.24	2.98
3.29	4.13
3.34	5.45
3.39	6.95
3.44	8.64
3.49	10.52
3.54	12.59
3.59	14.86
3.64	17.33
3.69	20.02
3.74	22.92
3.79	26.03
3.84	29.38
3.89	32.95
3.94	36.76
3.99	40.80
4.04	45.10

Table L-21: Emergency Spillway Inlet Rating Curves for Detention Ponds 13-14

Basin 13	
Depth (m)	Flow (cms)
2.70	0.00
2.75	0.19
2.80	0.61
2.85	1.22
2.90	2.02
2.95	2.98
3.00	4.13
3.05	5.45
3.10	6.95
3.15	8.64
3.20	10.52
3.25	12.59
3.30	14.86
3.35	17.33
3.40	20.02
3.45	22.92
3.50	26.03
3.55	29.38
3.60	32.95
3.65	36.76
3.70	40.80
3.75	45.10

Basin 14	
Depth (m)	Flow (cms)
2.48	0.00
2.53	0.19
2.58	0.61
2.63	1.22
2.68	2.02
2.73	2.98
2.78	4.13
2.83	5.45
2.88	6.95
2.93	8.64
2.98	10.52
3.03	12.59
3.08	14.86
3.13	17.33
3.18	20.02
3.23	22.92
3.28	26.03
3.33	29.38